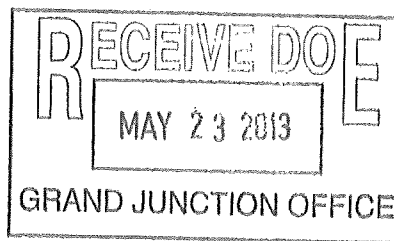




UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 17, 2013



Ms. Jalena Dayvault
Site Manager
U. S. Department of Energy
Office of Legacy Management
2597 Legacy Way
Grand Junction, CO 81503

SUBJECT: U.S. DEPARTMENT OF ENERGY REQUEST FOR U.S. NUCLEAR
REGULATORY COMMISSION CONCURRENCE ON U.S. DEPARTMENT OF
ENERGY PROPOSAL TO APPROVE THE GROUNDWATER COMPLIANCE
ACTION PLAN FOR THE LAKEVIEW OREGON PROCESSING SITE

Dear Ms. Dayvault

The U.S. Nuclear Regulatory (NRC) staff has completed its detailed review of the U.S. Department of Energy (DOE) fourth revised Groundwater Compliance Action Plan (GCAP), ML101930356, dated June 25, 2010, for the uranium mill processing site at Lakeview, Oregon. The documentation of this review is contained in the enclosed Technical Evaluation Report (TER), entitled "Review of the Draft Groundwater Compliance Action Plan UMTRCA Title I Lakeview, Oregon, Processing Site, Final Report."

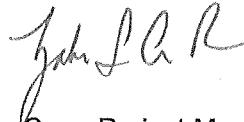
Through the review process, the NRC staff identified five issues associated with the draft GCAP: (1) the proposed groundwater compliance strategy as it relates to the hydraulic isolation from underlying aquifers, the domestic use of downgradient groundwater, and demonstration of the limited use of the groundwater; (2) determination of background concentration for molybdenum; (3) delineation of the contaminant plume boundary; (4) coverage of compliance monitoring wells, and (5) the proposed monitoring program. All issues are discussed and addressed in the TER.

The staff finds that the 2010 Lakeview Oregon processing site GCAP satisfies the requirements of the Uranium Mill Tailings Control Act of 1978, as amended, and the groundwater protection standards in Title 40 of the *Code of Federal Regulations*, Part 192 with the following conditions: (1) the DOE shall perform characterization and monitoring for sulfate and manganese as described in the GCAP Appendix A work plan; and (2) that the private resident Well 0543 located within the institutional control area continued to be monitored on a limited basis. If the monitoring data from future sampling events demonstrates that the water is no longer suitable for the current or future residents then the DOE shall provide a suitable alternate water source.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records component of NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at <http://www.nrc.gov/reading-rm/adams.html>.

If you have any questions regarding this letter, please contact Zahira Cruz, the Project Manager for the Lakeview Processing Site, at (301) 415-3808 or by e-mail to Zahira.Cruz@nrc.gov.

Sincerely,



Zahira Cruz, Project Manager
Special Projects Branch
Decommissioning and Uranium Recovery
Licensing Directorate
Division of Waste Management
and Environmental Resources
Office of Federal and State Materials
and Environmental Management Programs

Enclosure:
Technical Evaluation Report

Groundwater Compliance Action Plan for the Lakeview, Oregon, Processing Site

June 2010



U.S. DEPARTMENT OF
ENERGY

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Management

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**Groundwater Compliance Action Plan
for the Lakeview, Oregon,
Processing Site**

June 2010

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Plate 1—Lakeview Base Map with 1994 Photo Base
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Abbreviations

BLRA	baseline risk assessment
COPC	constituents of potential concern
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
GCAP	Groundwater Compliance Action Plan
kg	kilogram
IC	institutional control
MCL	maximum concentration limit
mg/L	milligrams per liter
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
PEIS	Programmatic Environmental Impact Statement
RAP	Remedial Action Plan
ROD	Record of Decision
Surface EA	Surface Environmental Assessment
TDS	total dissolved solids
UMTRA	Uranium Mill Tailings Remedial Action (Project)
UMTRCA	Uranium Mill Tailings Radiation Control Act

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1.0 Introduction

This Groundwater Compliance Action Plan (GCAP) presents the groundwater compliance strategy for the Lakeview, Oregon, Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I Processing Site.

1.1 Previous Site Documentation

The GCAP is based on a U.S. Department of Energy (DOE) evaluation of information from the following sources:

- Engineering Assessment for the site (DOE 1981),
- Surface Environmental Assessment (Surface EA) (DOE 1985),
- *Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Site at Lakeview, Oregon* (RAP) (DOE 1992),
- Baseline Risk Assessment (BLRA) (DOE 1996a),
- Information gathered from 1999 to present.

All the documentation compiled through 1999 was included in an appendix to a 1999 draft version of this GCAP which was previously provided to the regulators (DOE 1999a). Typically, extensive information regarding the conceptual site model for Uranium Mill Tailings Remedial Action (UMTRA) Project sites is included in a site observational work plan. However, a more streamlined approach was taken for the Lakeview site because of the low levels of groundwater contamination that were present, and a site observational work plan was not prepared. Instead, relevant background research, aquifer characterization information, and monitoring data are provided in Sections 2.0 of this GCAP.

This GCAP will serve as a stand-alone modification to the RAP (DOE 1992) to address groundwater restoration and compliance with the U.S. Environmental Protection Agency (EPA) groundwater protection standards for the UMTRA Project Title I sites. Responses to *Request for Information—Ground Water Compliance Action Plan for the Lakeview, Oregon, UMTRA Project Site* received from the Nuclear Regulatory Commission (NRC) on February 4, 2004, and subsequent communications are included in the text of this document. The GCAP will be the NRC concurrence document for compliance with Subpart B of Title 40 *Code of Federal Regulations* Part 192 (40 CFR 192) for the Lakeview processing site.

1.2 Regulatory Framework

The compliance strategy for the Lakeview site is based on the compliance strategy selection framework following the steps presented in the *Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (PEIS) (DOE 1996b). National Environmental Policy Act (NEPA) issues and environmental concerns were addressed in a 1999 Environmental Checklist for the site. The public has been actively involved in the decision-making process, as demonstrated in an appendix to a 1999 draft version of this GCAP which was previously provided to the regulators (DOE 1999a).

The main regulatory driver for groundwater cleanup at this site is Subpart B of 40 CFR 192, which lists the hazardous constituents and cleanup standards for which NRC has regulatory authority. NRC has provided the following discussion regarding groundwater standards in its Standard Review Plan for Title I Sites (NRC 1993):

“DOE has developed a standard constituent list for inorganic screening of tailings-fluid or ground-water samples. Table 4 lists these constituents (DOE, 1989a). Each of the Table 4 constituents are included in the list of potential hazardous constituents, if they are identified above the detection limit. A comparison of Table 4 to Appendix VIII indicates that not all of the constituents in Table 4 are considered hazardous. Consequently, only those constituents (or elements of hazardous compounds) that exceed the method detection limit, *and* are listed in Appendix VIII (40 CFR 261) OR Table A (40 CFR 192); should be included in DOE’s hazardous constituent list.

The elements of a hazardous compound should also be listed, if the combination of those elements detected in the tailings pore fluid would produce a hazardous compound under the right geochemical conditions in the subsurface. For example, if strontium and sulfide ions have been detected in the tailings pore fluid, and the geochemical conditions in the uppermost aquifer favor the precipitation of strontium sulfide (listed in Appendix VIII); then strontium and sulfide should be included as a hazardous constituent. However, if aluminum ions are detected and no corresponding anions would produce a hazardous compound under the subsurface geochemical conditions; then aluminum should not be listed as a hazardous constituent.”

The Appendix VIII list referred to in the Title I Standard Review Plan (dated June 1993, and predating groundwater regulations) is the same list that was incorporated into the subsequent 40 CFR 192 groundwater regulations as Appendix I.

Based on recent monitoring results, groundwater at the Lakeview site is in compliance with standards for all “hazardous constituents” listed in 40 CFR 192. However, the BLRA for the site (DOE 1996a) identified other site-related constituents (e.g., nonregulated “indicator parameters”, which include sulfate and manganese) that have been elevated historically and have been used to estimate the extent of the site-related influence in the uppermost aquifer. Collectively, these hazardous constituents and indicator parameters are referred to as constituents of potential concern (COPCs) in this document. Unlike Title II sites, where NRC has the authority to add constituents not on this list to a specific license (Criterion 13 of 10 CFR 40, as discussed in NUREG 1620), this provision does not apply to Title I sites. Therefore, while sulfate and manganese are important indicator parameters for understanding hydrogeologic conditions of the Lakeview site (and are discussed in some detail in Section 2.0), they have no enforceable standards under 40 CFR 192.

1.3 Groundwater Compliance Status

Eleven site-related COPCs were previously identified in the BLRA for the site (DOE 1996a) and a draft GCAP was subsequently submitted in 1999. The draft GCAP proposed a “no remediation” compliance strategy for the site because of the presence of widespread ambient contamination not related to milling activities. At that time, some regulated constituents did exceed standards. As a result, and to ensure protectiveness, institutional controls (ICs) were established to prevent well installation in the area most likely to be affected by site-related COPCs (IC boundary is shown on Figure 2–5). Currently, completion of wells within the IC boundary to depths above 250 feet (ft) is prohibited. The ICs are further discussed in Appendix B.

To support selection of a compliance strategy and to establish appropriate IC boundaries, data were collected to adequately characterize the regional and site-specific hydrogeology. Results of these studies are discussed in Section 2.3 of this GCAP. These discussions focus primarily on the use of sulfate (and to a lesser extent manganese) as an indicator parameter. Since that time, monitoring results have allowed the elimination of most COPCs on the basis of comparison with 40 CFR 192 standards or background levels. Each COPC identified in the BLRA is discussed in Section 2.3 of this GCAP. With the exception of sulfate and manganese, all of these COPCs can be eliminated from further consideration based on this comparison. Sulfate and manganese are not listed in Appendix I of 40 CFR 192, nor are any of the dominant species found at the Lakeview site (manganese sulfate, sodium sulfate, and calcium sulfate); therefore, they are nonregulated and no remediation or further actions, including groundwater monitoring, are required at the site.

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2.0 Site Information

Discussions in this section provide the technical basis for determining the groundwater compliance strategy for the site. This section includes information relevant to characterizing the aquifer beneath the site and provides historical and recent groundwater monitoring results.

2.1 Location

The Lakeview site is approximately 1.5 miles north-northwest of the town of Lakeview in Lake County, Oregon (Figure 2–1). The former mill site is located east of County Road 2-18 and north of Missouri Avenue in Sections 3, 4, 9, and 10, Township 39S, Range 20E, Washington Meridian at 42 degrees 12 minutes 43 seconds north latitude and 120 degrees 22 minutes 09 seconds west longitude (Plate 1).

2.2 Remedial Action History and Current Land Status

The 258-acre site includes areas formerly occupied by seven raffinate or evaporation ponds and a tailings pile and mill buildings. From 1986 to 1988, 736,000 tons (943,630 cubic yards) of uranium mill tailings and other process-related solid waste were removed from the processing site and moved to a disposal cell on the former Collins Ranch about 7 miles northwest of Lakeview. In some areas of the former raffinate or evaporation ponds, contaminated materials were removed from depths of more than 50 ft below ground surface (Steward-Smith 2002). The cost of the project was \$24,571,000 (DOE 1999c).

The former mill site is located on private land. Pacific Pine Products, a lumber company, now uses the former mill buildings. Other small businesses have constructed buildings in the immediate area of the former mill buildings. Barbed-wire fences enclose the former evaporation pond and tailings pile areas in open fields. The entire site is zoned for commercial–light industrial use. The southern portion of the area is part of Lake County’s urban growth boundary where commercial businesses are being developed. Other areas in and near the site are also being developed for commercial businesses.

2.3 Site Characteristics

2.3.1 Climate

The Lakeview area is characterized by low humidity, frequent sunny days, and moderate seasonal temperature ranges. The annual temperature averages 46 °F and ranges from an average of 27 °F in January to 67 °F in July (DOE 1996a). The average annual precipitation is 14 inches (DOE 1996c). The area can be generally described as a semi-desert.

2.3.2 Geologic Setting and Hydrogeology

2.3.2.1 *Regional Setting*

The Lakeview site sits at the base of the Warner Mountains to the east and is located within one of several fault-block basins in south-central Oregon, which are characterized by the presence of closed-basin lakes (Phillips and Van Denburgh 1971). The regional geology is dominated by these fault block structures, as evidenced by the normal fault along the west side of the Warner

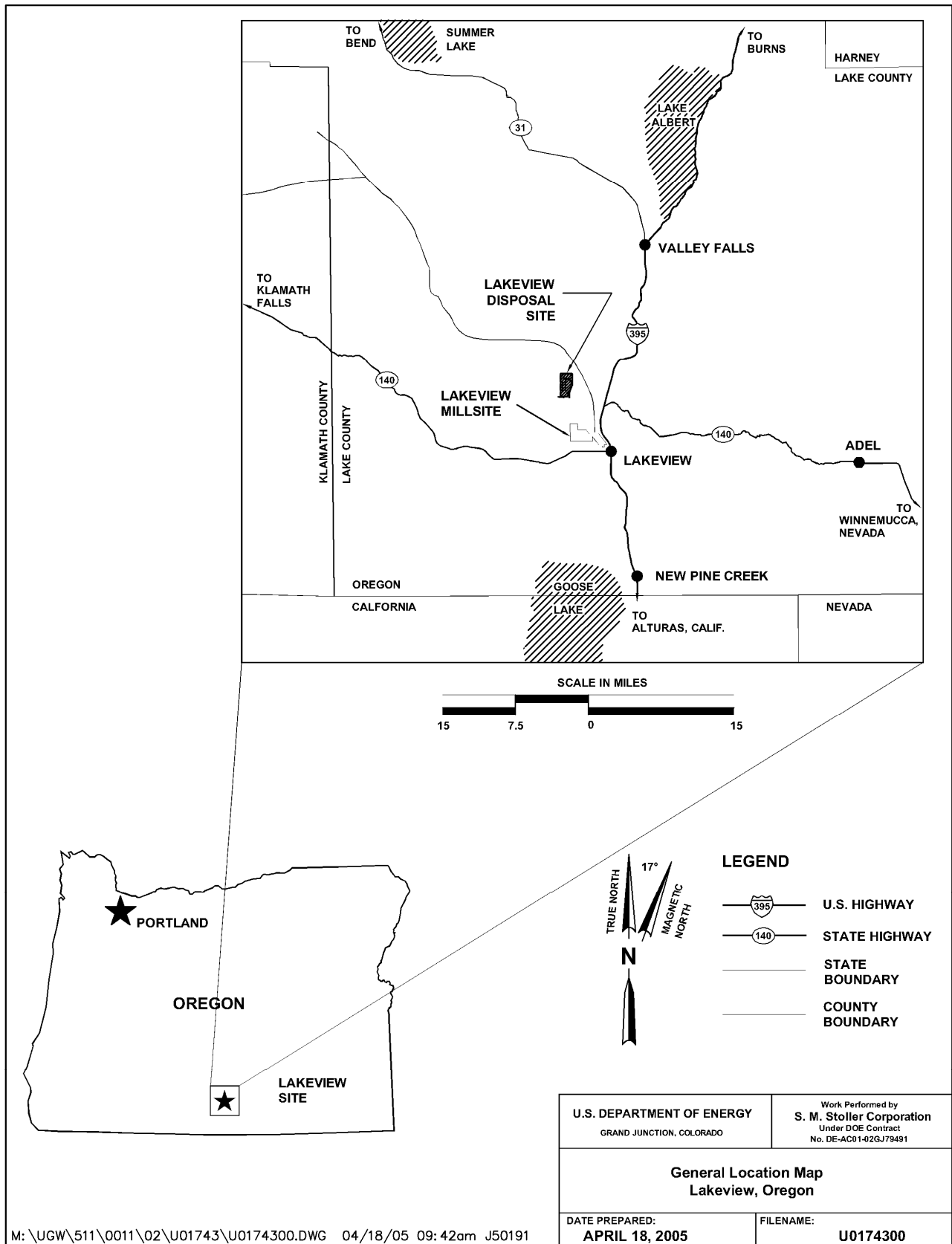


Figure 2-1. General Location Map Lakeview, Oregon

Mountains and the Goose Lake graben. Tertiary volcanic rocks occur in the upthrown fault blocks east and north of Lakeview, nearest the former mill site. Alluvial and lacustrine sediments within the graben may reach thicknesses of 2,000 ft in the Lakeview area (DOE 1992).

Generally, individual pulses of sediment are coarser near the boundaries of the basin and become finer grained toward the center. The relative rate of basin subsidence and long-term climatic variations control the rates and types of deposition in various parts of the basin. Differential subsidence in grabens as large as the Goose Lake basin is common, which can also contribute to contemporaneous deposition of coarser and finer sediments in various areas. Wetter climatic periods creating long-lived lakes can produce finer-grained and more laterally continuous deposits. This combination of tectonics and climatic factors produce the heterogeneous, unconsolidated sediment pile in the basin consisting of discontinuous clays, sands, and gravels. This sequence is demonstrated in the cross sections shown in Figure 2–2 and Figure 2–3, which were prepared from lithologic logs of boreholes. The cross section locations are shown on Plate 1. Generally, in this geologic setting groundwater would move toward the center of the basin where groundwater flow has an upward component, as shown on Figure 2–4, which is an illustration from EPA’s Groundwater Protection Strategy (EPA 1988). This is consistent with the characteristics of unconsolidated sedimentary hydrogeologic units as described by the U.S. Geological Survey (USGS 2004). The USGS report noted that in settings like this, vertical hydraulic conductivities are typically one to three orders of magnitude less than the horizontal conductivities. Consequently, contaminants in shallow aquifers toward the center of the basin spread only slowly and through small areas.

2.3.2.2 *Site-Specific Setting*

Historical wells have tapped shallower and deeper portions of the aquifer (DOE 1996a). The shallow water-bearing zone (30 ft deep or less) and the deeper zone (60 to 75 ft deep) are partially separated by interfingering layers of clayey sediments. Aquifer testing has demonstrated that the two zones are somewhat hydraulically connected, though this connection is restricted (DOE 1996a). Further study of lithologic logs from wells installed by DOE during the surface remediation program suggests that the upper and lower intervals may be laterally continuous over limited areas but generally lack widespread lateral continuity. In the predominantly east-west cross section A–A’ (Figure 2–2), sands and gravels are separated intermittently by clays and silts. Upper and lower zones may be distinguishable in several well pairs, but the zones are indistinguishable in other areas. Similarly, the predominantly north-south cross section B–B’ (Figure 2–3), located farther out in the basin, does not consistently demonstrate separation of zones. However, the continued interfingering of finer- and coarser-grained sedimentary units with depth can act as an effective hydrologic barrier.

In the area of the former mill site and in areas south of the site, the groundwater in both the upper and lower water-bearing zones moves from northeast to southwest at rates ranging from 50 to 160 ft per year (DOE 1996a). Figure 2–5 shows the 2002 potentiometric surface after the installation of three temporary wells to obtain water levels in the area south of the former mill site. It also shows a general southwesterly flow direction for the shallow groundwater, away from the nearby Warner Mountains.

Groundwater from a geothermal artesian source northeast of the site flows southwest through the subsurface beneath the western side of the site and feeds springs that surface north of the site at

Hunters Hot Springs. Water from the hot springs feeds Hunters Creek, which flows to the southwest and enters into Warner Creek, which flows along the western border of the site.

2.3.3 Groundwater and Surface Water Quality

2.3.3.1 Regional Water Quality

As noted in the BLRA (DOE 1996a), soils in the vicinity of the site are described by the U.S. Department of Agriculture Soil Conservation Service as “sodic and saline” and unfit for lawns, topsoil, and embankments, due to excess salt. Sediments comprising the alluvial aquifer were deposited in a closed-lake setting and contain considerable natural salt content. The soluble salts can only be removed by overflow into another basin, by incorporation into the lake bottom as interstitial brines, or by wind transport of desiccated evaporite minerals (Phillips and Van Denburgh 1971). A highly saline lake (Goose Lake) once covered the entire area and undoubtedly served as a source of groundwater recharge. Only the remnants of this larger lake currently exist today as the smaller Goose Lake, Summer Lake, and Lake Abert (Langbein 1962). Goose Lake has dried up several times in recent history and has contributed large amounts of salts into the sediments. The current water quality of Goose Lake is poor and is not of drinking quality. Other graben-controlled lakes in this semiarid area have high salt contents (Phillips and Van Denburgh 1971). The USGS has described graben-controlled lacustrine depositional environments in their *Ground Water Atlas of the United States* (USGS 1994). That report notes that “. . .unconsolidated-aquifer deposits generally yield freshwater but locally yield saltwater, especially in south-central Oregon and coastal areas.” This supports the interpretation of naturally saline water in the Lakeview area.

Groundwater quality is generally better to the east of the site where it is closer to the source of fresh surface-water recharge in the mountains. Farther west, where groundwater has been in more prolonged contact with the salty lake sediments, water quality is generally poorer. It is possible that over time, as groundwater flows through and reacts with the salty lake deposits, some dissolution of the salt occurs, and concentrations of salt-related contaminants become elevated. Figure 2–4 depicts a geologic and hydrologic setting much like that at Lakeview. The discontinuous nature of the sediments in the Lakeview area may also result in local stagnation of groundwater, which would further promote reaction of the groundwater with the sediments. A study of closed desert basins by Duffy and Al-Hassan (1988) indicates that solute gradients naturally exist in such groundwater systems, both laterally and vertically. Generally, salinities increase with distance from the groundwater recharge zones (i.e., adjacent to the mountains) and are highest in basin centers. They further indicate that salinities appear to decrease with depth at locations toward the basin centers. This is consistent with observations made at the Lakeview site, though the situation at Lakeview is further complicated by the presence of the geothermal area as well as site-related influences.

Mr. Loren Lucore of Lucore Drilling Company, who has drilled shallow water wells in the Lakeview area for 30 years, was interviewed in 2002 about the locations of water-bearing zones and the general water quality in these zones. Mr. Lucore stated that generally, fine sand and clay make up the uppermost 30 ft of the sediments, which can yield water of poor quality. An unctuous blue clay is present from about 30 ft to 45 ft in many but not all locations, and a black sand to gravel extends from 45 to 60 ft that usually yields sufficient water for well production.

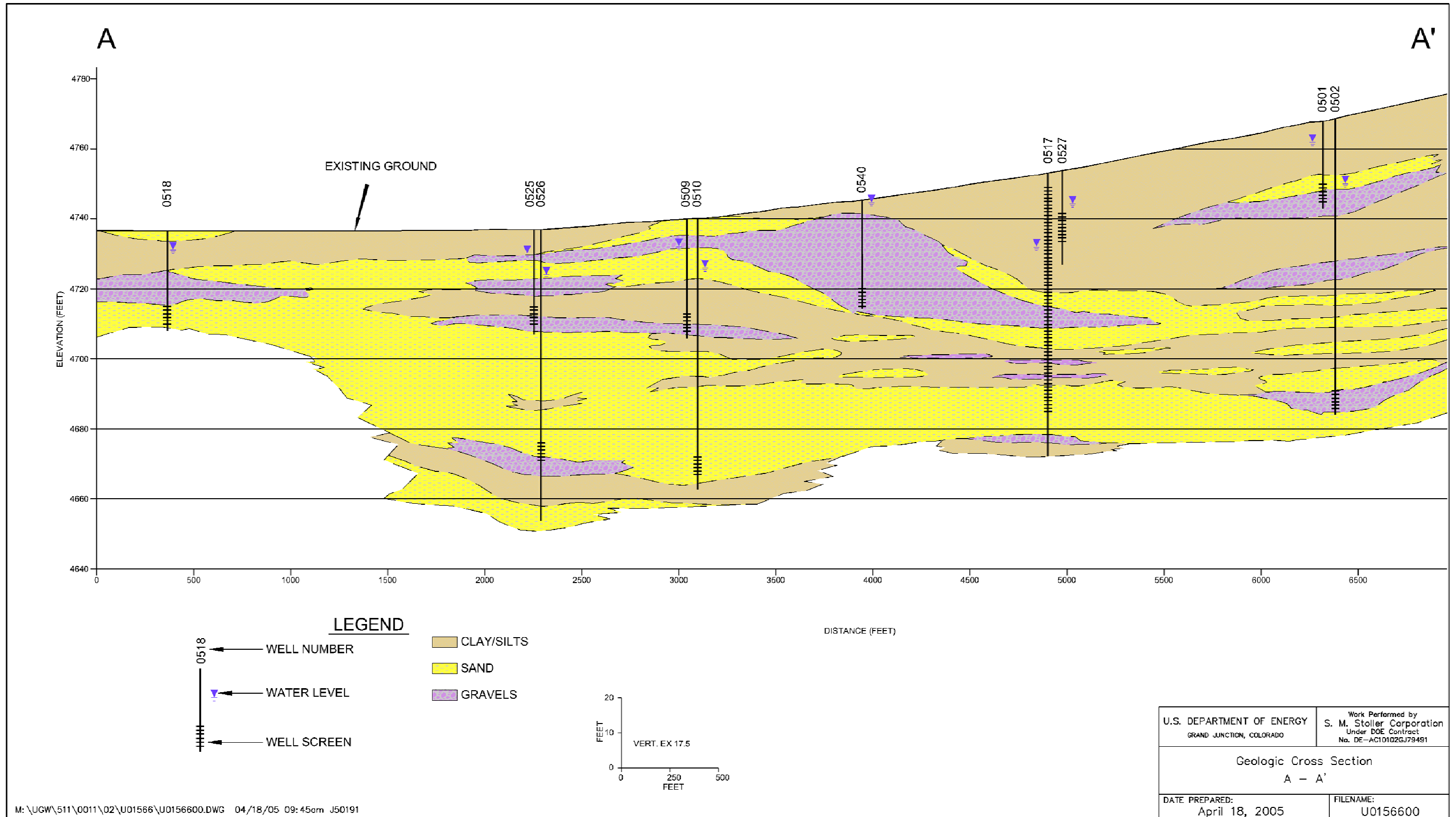


Figure 2-2. Geologic Cross Section A-A'

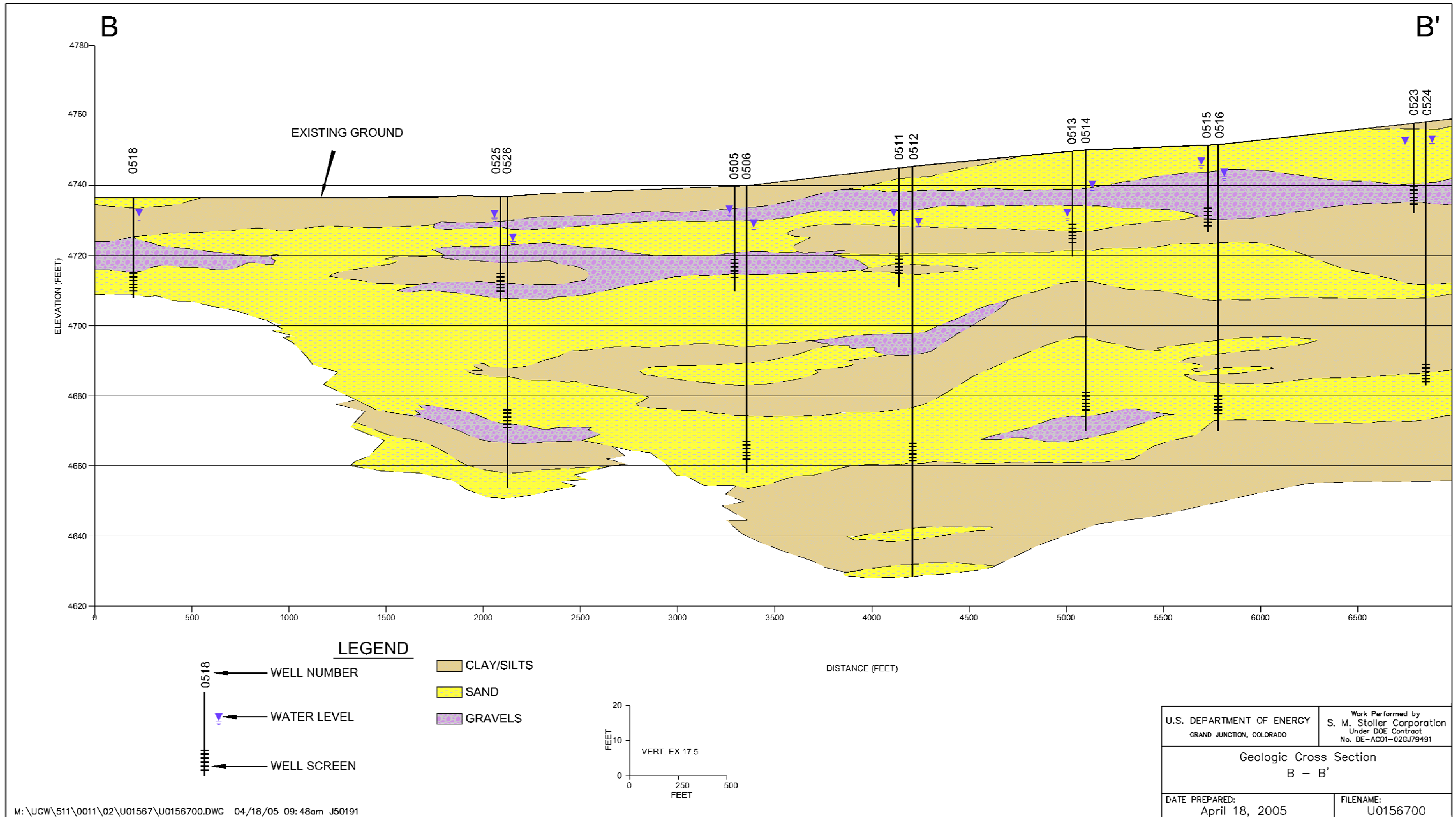


Figure 2-3. Geologic Cross Section B-B'

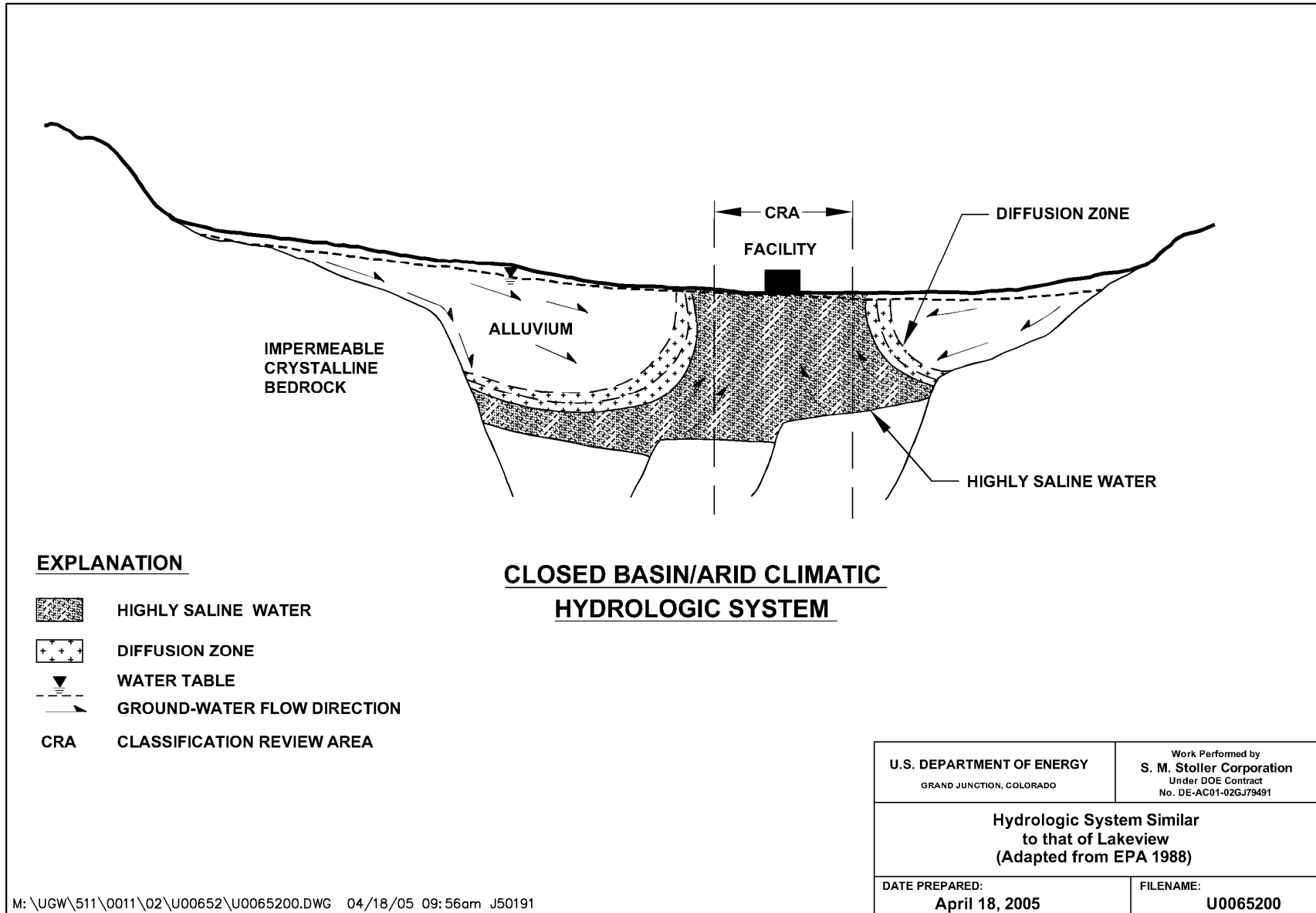
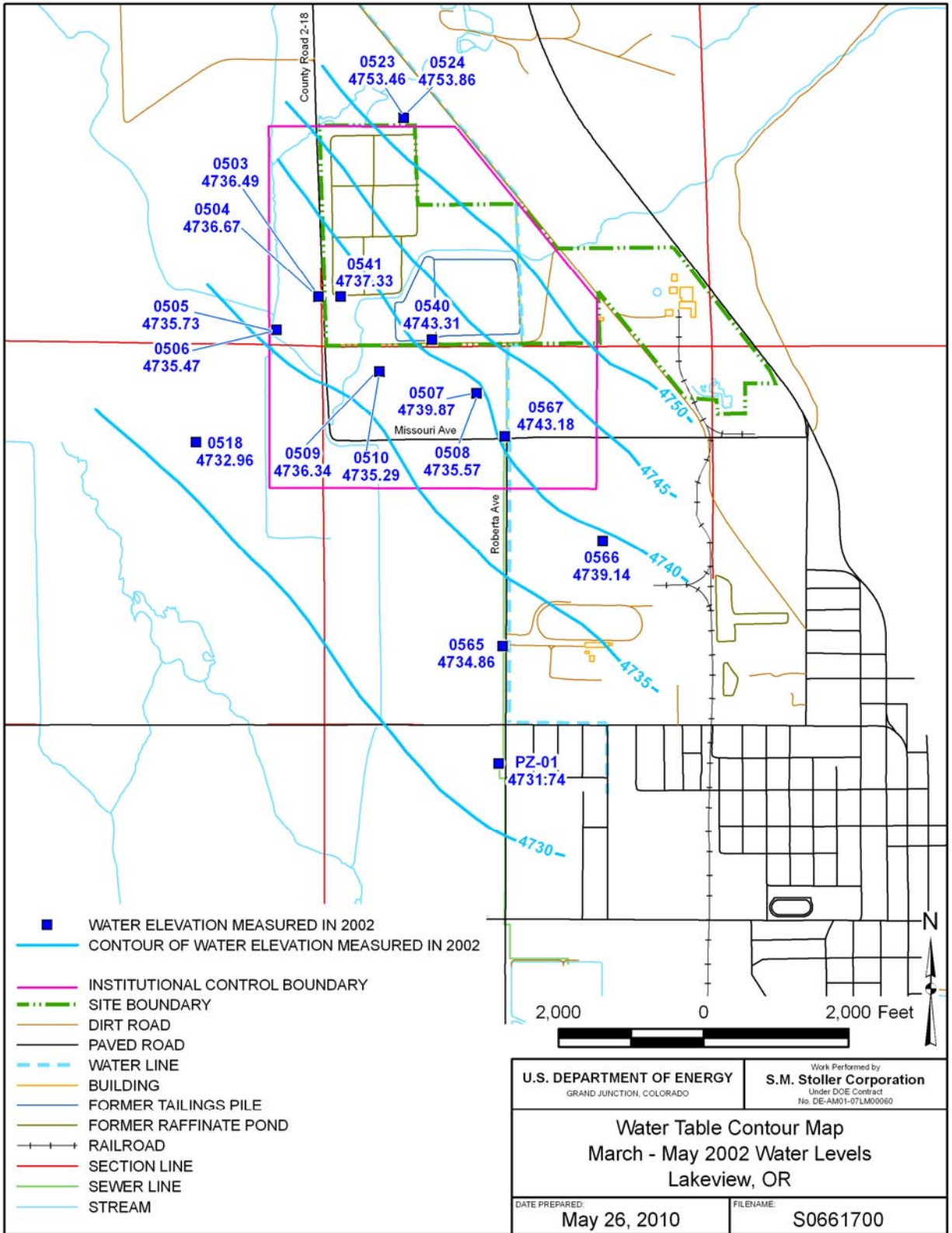


Figure 2-4. Hydrologic System Similar to That of Lakeview



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Figure 2-5. Water Table Contour Map March-May 2002 Water Levels, Lakeview, Oregon

Below 60 ft are various sands, gravels, and clays. Water quality is generally better at this depth, though it is poor enough in many locations that private well users install some type of treatment units to make the water potable. Wells several hundred feet deep have much better quality water. This interpretation of water occurrence generally agrees with lithologic logs.

Typically, major chemical components of waters in these closed-basin settings are sodium, chloride, and sulfate (Drever 1997). Other lesser components include boron, arsenic, molybdenum, and manganese (Piovano et al 2004, Tanji et al 1992). These constituents are commonly detected in Lakeview area groundwater.

A large portion of the Goose Lake valley floor receives irrigation water. According to the BLRA, surface water from Thomas and Warner Creeks is diverted to a system of unlined irrigation ditches that serve the area west, southwest, and south of the site (DOE 1996a). Studies in other irrigated areas in the arid to semiarid west have shown that irrigation can lead to dissolution of salts in saline subsurface materials; subsequent discharge of salty groundwater to rivers in the area can have a significant deleterious effect on surface water quality (DOI 1999).

Arsenic, boron, and molybdenum concentrations are elevated in waters associated with the geothermal area northeast of the former mill site and are most likely a product of that geothermal activity (DOE 1996a). Arsenic is known to be associated with geothermal systems in the western United States. Boron may also be present in subsurface geothermal fluids, or it may be a result of the dissolution of subsurface salts by those fluids. It is known that boron is a significant trace component in the subsurface salts in the Lakeview area (Phillips and Van Denburgh 1971). Heated geothermal waters are likely responsible for dissolving and releasing significant amounts of soluble constituents to the groundwater.

2.3.3.2 *Site-Specific Water Quality*

Water quality in the vicinity of the Lakeview site varies widely as a result of several influences, including the general hydrologic setting, the geothermal area, and the former uranium-milling activities. This variability makes the interpretation of milling-related effects on groundwater quality complex. Any site-related COPCs would have intermixed with naturally occurring regional contamination.

2.3.3.2.1 *Historical Site-Related Contaminant Sources*

The BLRA compared groundwater beneath the site with groundwater assumed to be background and determined that groundwater beneath the Lakeview site was contaminated by former uranium-ore processing operations (DOE 1996a). However, historical knowledge of the Lakeview site raises some doubt that the site is the major source of elevated groundwater constituents in the area.

The site was operational for only a short period of time (less than 3 years from February 1958 until November 1960) nearly 50 years ago. Contaminated tailings and soils, the predominant sources of groundwater COPCs, were removed 22 years ago. Monitoring at the site has occurred for approximately the last 24 years. At other UMTRCA sites with contaminants similar to those at Lakeview, decreasing contaminant concentrations have generally been observed over a shorter time frame when those contaminants are milling related. At Lakeview, concentrations of the

most prevalent constituents (including sulfate and manganese) have remained relatively constant. No significant decreasing trends have been observed. Uranium, the constituent that was the target of the milling operation, is virtually absent in the groundwater. It is possible that uranium and other mill-related constituents have been flushed from the site and replaced by ambient groundwater.

Data collected during preparation of the Surface EA (DOE 1985) and the surface remedial action plan (DOE 1992) for the former mill site indicate that the major source of elevated constituents in groundwater was likely the raffinate ponds rather than the tailings pile. The pore water analytical results from the raffinate ponds and tailings pile are included in Appendix C (DOE 1992). Tailings were relatively dry (though they did contain some slimes), but the raffinate ponds were used as storage areas for liquids that remained after ore-processing activities ceased. Therefore, the raffinate ponds could have served as an ongoing source until they were remediated.

2.3.3.2.2 Background Water Quality

Background groundwater quality is groundwater that has not been influenced by the former uranium-milling process. The term “background,” as used in this document, does not necessarily mean that the water is pristine; background groundwater in the Lakeview area is influenced by various non-site-related factors. For the Lakeview site, historically two types of background—geothermal and nongeothermal—have been distinguished to take into account the presence of the hot springs.

The background geothermal samples were collected from the hot springs area located upgradient of the site. These samples are believed to be representative of geothermal background. The influence of the geothermal waters on the site’s groundwater appears to be more important near the northern and western portions and becomes less important in the eastern and southern portions of the site.

Throughout the valley, which is largely nongeothermal, groundwater quality is known to be generally poor (DOE 1996a). This is not reflected in the nongeothermal background sampling that was performed in the initial characterization for the Lakeview site. The nongeothermal well pair used as background was located near the base of the mountains along Hammersley Creek. Because this area essentially receives recharge directly from the mountains, the water quality may not be indicative of background water quality in the main portion of the valley.

Differentiating between naturally occurring and milling-related constituents is difficult because the best site-related indicators (sulfate and manganese) are also found at naturally elevated concentrations in the Lakeview area. It is unclear what concentrations of sulfate and manganese would be a cutoff between background and site-related concentrations.

2.3.3.2.3 Lateral Extent of Site-Related COPCs

Although not regulated, discussions of sulfate and manganese provide important information for understanding the hydrology at the site.

- Site-related source areas were the former tailings pile and the former raffinate ponds. For both sulfate and manganese, the primary source was the ponds.

- Water level measurements in the temporary wells installed in 2002 indicate that groundwater flow direction is to the southwest (Figure 2–5); thus, any site-related constituents would have moved in that direction.
- The groundwater flow direction is confirmed by COPC distribution associated with former site source areas. Well 0503 represents the former raffinate pond source area; well 0505 lies directly downgradient. Well 0540 represents the tailings pile source area paired with downgradient well 0509. As shown in the time-concentration plots in Figure 2–6 and Figure 2–7, manganese and sulfate concentrations in source area wells 0503 and 0540 have remained consistently higher than concentrations in their respective downgradient wells 0505 and 0509, indicating that COPCs are attenuating with distance from the source areas.
- Monitoring well 0540 has shown declining concentrations of sulfate and manganese indicating significant attenuation over time; this is the well that has been indicative of the highest source concentrations associated with the tailings pile.
- The concentrations of both sulfate and manganese in the downgradient wells have remained relatively constant, or have decreased over the last 15 years. This suggests that the extent of the affected areas are not expanding, but are basically stable or shrinking in size.
- Historical data suggest the presence of a strong geothermal influence west of the IC boundary, which is discussed in Appendix B. Therefore, elevated constituents (sulfate and manganese) in this area may not be solely site-related. Previously, isotopic analyses were performed to distinguish different sources of sulfate. This information is summarized in a figure included in Appendix A (DOE 1992).
- Wells 2,500 ft south of the site boundary along Roberta Avenue show an isolated area with high concentrations of manganese. Sulfate is also especially elevated in one well. Because this isolated area is nearly one-half mile from the site and is not in the flow path of groundwater migrating through the site, it has been determined that these elevated concentrations are not site-related. The concentrations could be a result of leaching by irrigation water. Spot plots for manganese and sulfate generated for the 2002 GCAP are included as Figure 2–8 and Figure 2–9, respectively.
- In the past it has been suggested that other non-site-related sources of groundwater contamination are located to the east of the site (DOE 1996b).

2.3.3.2.4 Vertical Extent of Site-Related COPCs

As previously stated, although not regulated, discussions of sulfate and manganese provide important information for understanding the hydrology at the site.

DOE has determined that it is highly unlikely that there is any influence of shallow site-related constituents on the aquifer at depths below the 250 ft IC boundary and that no further characterization of vertical hydraulic connectivity is warranted. This determination is based on:

- Low concentrations of site-related groundwater constituents in the shallow aquifer.
- Low volumes of waste produced at the processing site in its 3 years of operation.
- The considerable source-removal efforts.
- The considerable depth (over 200 ft) that the water would need to travel through, during which it would undergo significant dilution and attenuation.

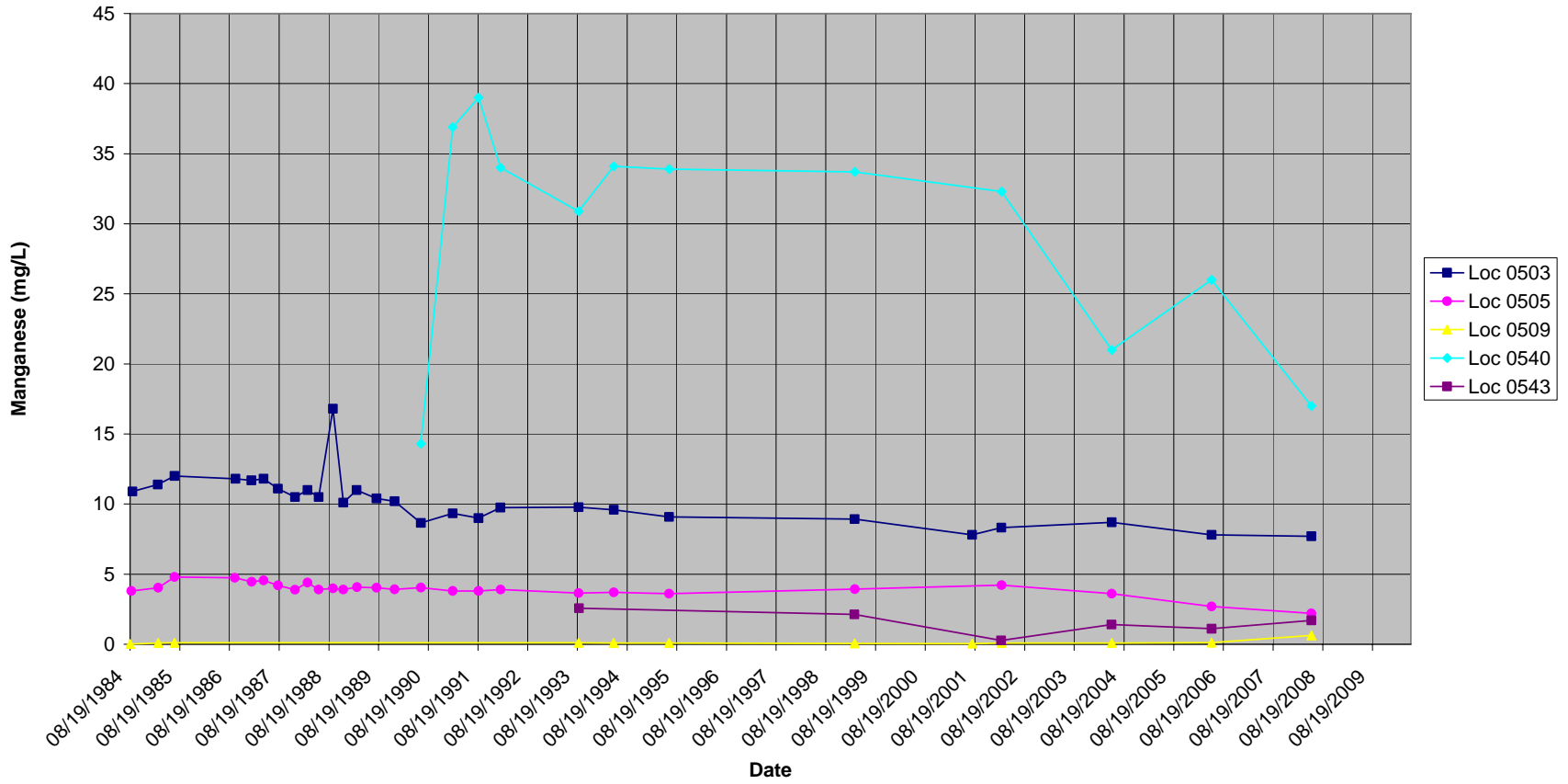


Figure 2-6. Manganese Concentrations at the Lakeview, Oregon Site

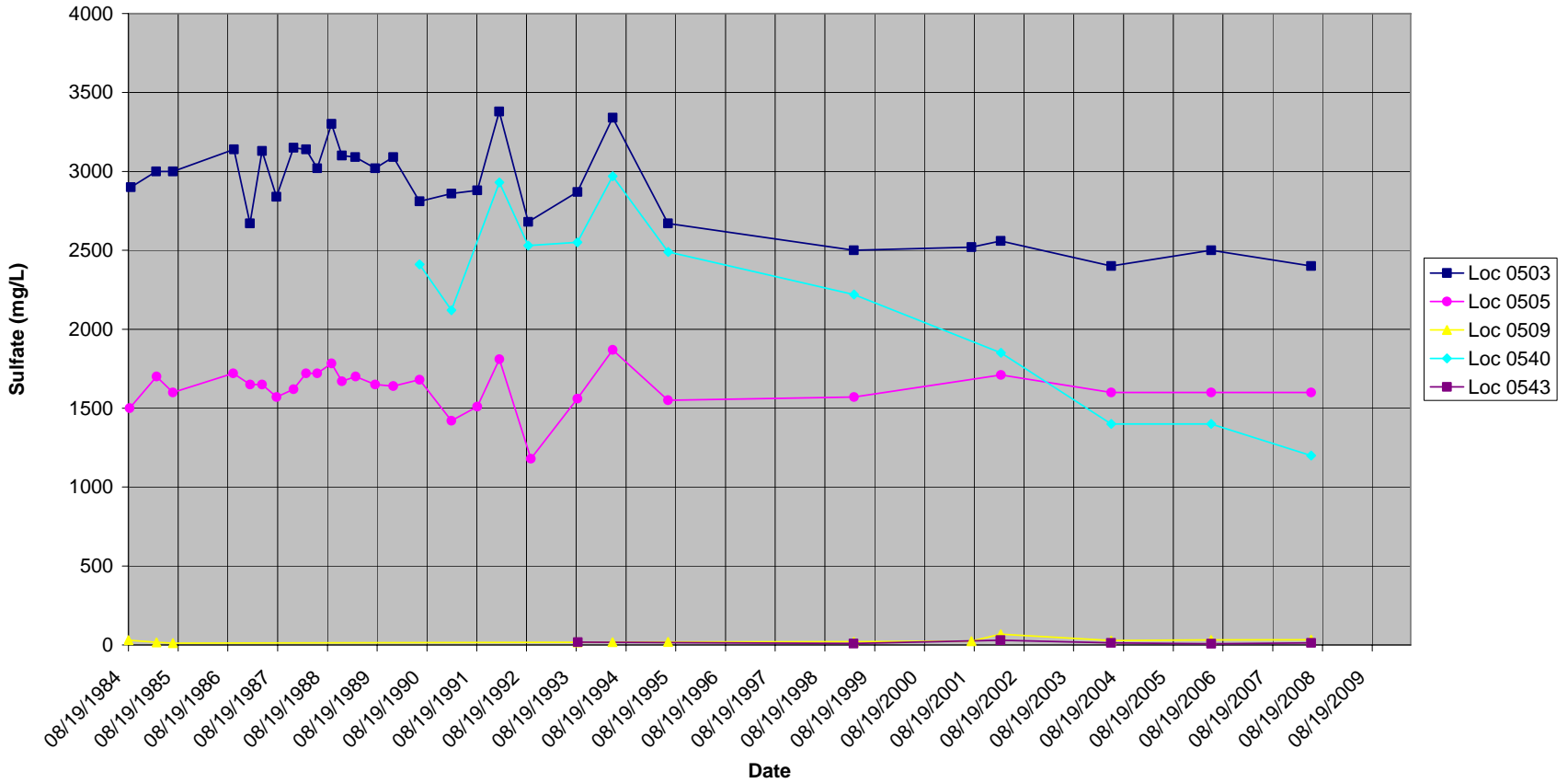


Figure 2-7. Sulfate Concentrations at the Lakeview, Oregon Site

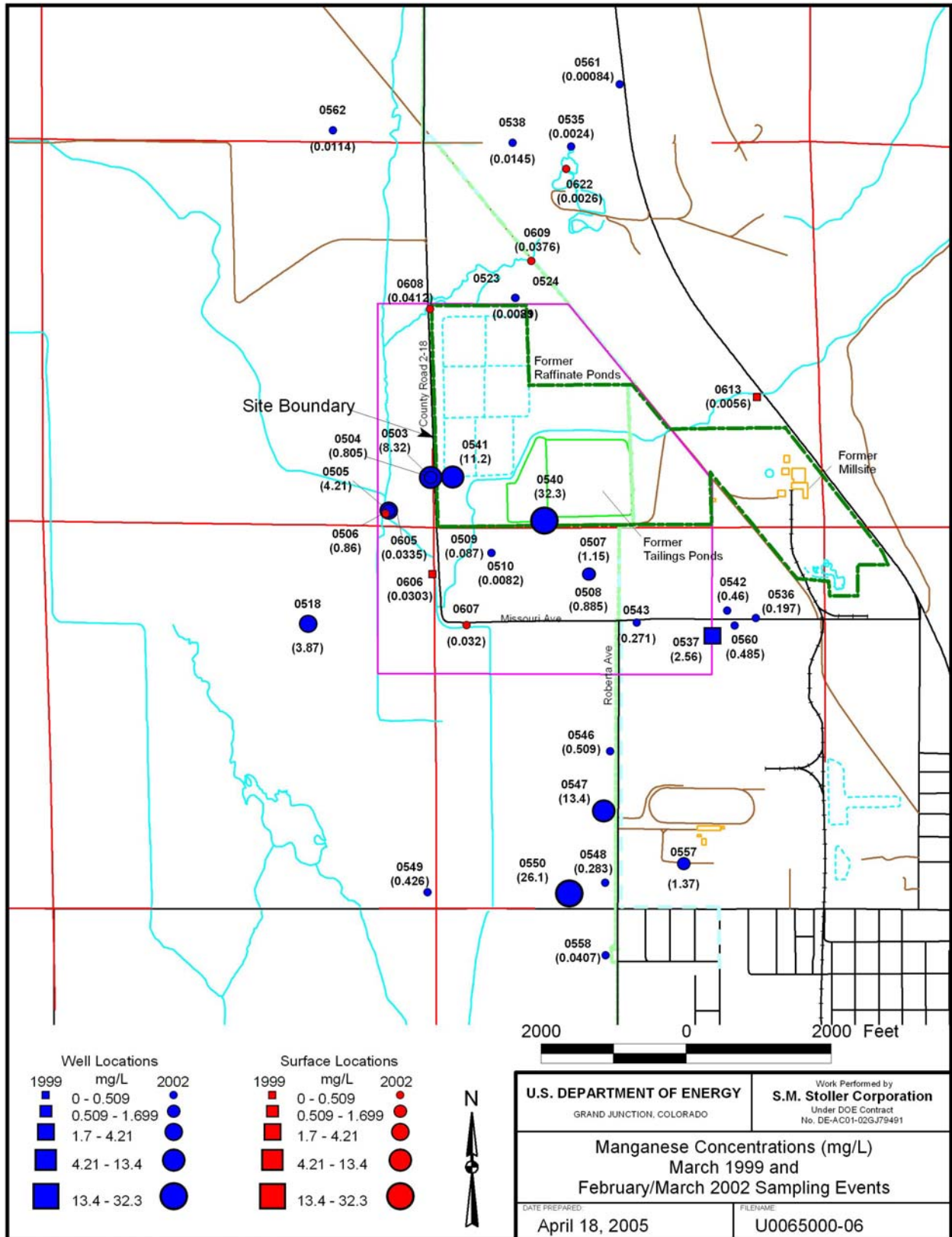
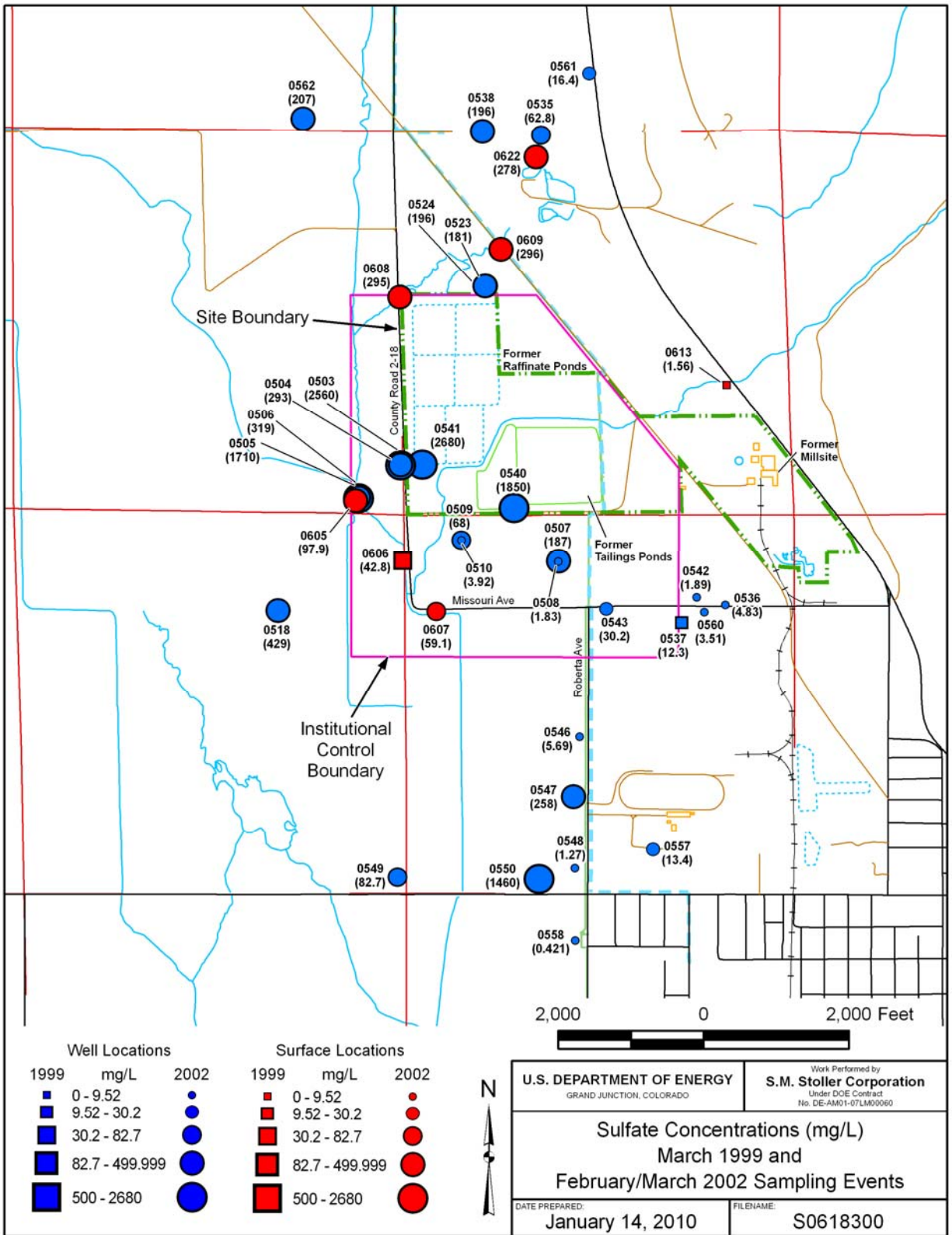


Figure 2-8. Manganese Concentrations (mg/L) March 1999 and February/March 2002 Sampling Events



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Figure 2-9. Sulfate Concentrations (mg/L) March 1999 and February/March 2002 Sampling Events

- The presence of the numerous interbedded clays and sands that would adsorb COPCs and would also impede vertical groundwater flow.
- The potential for an upward hydraulic gradient from deeper zones, as characterized by the general geologic basin setting (see Figure 2–4).
- Evidence from deeper wells near the site that indicate the presence of an upward hydraulic gradient. This evidence can be seen in numerous well-pairs, as shown in Figure 2–2 and Figure 2–3.
- There is no evidence that milling has affected deeper wells in the vicinity of the site. Water quality is significantly and consistently better at depth, as indicated by the comparison of water quality data for shallow and deep well pairs shown in Table 2–1. Well locations for all wells identified in Table 2–1 can be seen on Plate 1.

Table 2–1. Analytical Results from Selected Well Pairs

Monitoring Well Number ^a	Depth to Top of Well Screen (ft below ground surface) ^b	Constituent Range for All Historical Monitoring Data			
		Sulfate (mg/L)	Manganese (mg/L)	Iron (mg/L)	TDS ^c (mg/L)
503	18.16	2,300–3,380	7.5–12.0	0.38–9.8	5,910–8,020
504	71.23	180–299	0.27–0.889	< 0.03–0.21	710–920
505	21.1	1,420–1,870	0.98–4.8	< 0.03–7.4	3,890–4,190
506	75.19	240–336	0.49–0.86	< 0.03–0.37	844–1,040
513	15.01	2,200–2,500	13.9–25.0	15.5–27.0	7,692–9,022
514	67.92	30–58	< 0.01–0.04	< 0.03–0.05	320–354

^aCo-located wells (paired wells) are 0503 and 0504, 0505 and 0506, and 0513 and 0514.

^bAll well screen lengths are 5 ft.

^cTDS = total dissolved solids

2.3.3.2.5 Discussion of Historical COPCs

In the BLRA, based on comparison with background groundwater, the eleven COPCs identified in the alluvial aquifer were arsenic, boron, iron, manganese, molybdenum, nickel, sodium, chloride, sulfate, uranium, and polonium-210 (DOE 1996a). Monitoring was discontinued for four of the constituents (boron, iron, nickel, and polonium-210) starting in 1999, because the risk posed by these contaminants was insignificant.

Of the COPCs retained for monitoring (arsenic, manganese, molybdenum, chloride, sulfate, sodium, and uranium), arsenic, molybdenum, chloride, and sodium were subsequently eliminated based on the following evaluation:

- **Arsenic:** Evaluation of 2006 groundwater analyses indicated that only one well contained arsenic exceeding the maximum concentration limits (MCLs) established in 40 CFR 192. Specifically, arsenic was detected in well 0503 during the May 2006 sampling event at a concentration of 0.097 milligram per liter (mg/L), which was nearly twice the 0.05 mg/L MCL. Most of the elevated arsenic concentrations from historical sampling can be attributed to the occurrence of geothermal water. Water collected at location 622, in the Hunters Hot Springs pond, where geothermal water surfaces as a geyser, contained up to 0.186 mg/L

arsenic. Sampling in the pond was discontinued after 2002. Groundwater analysis for arsenic was discontinued after 2006.

- **Molybdenum:** In the past, concentrations of molybdenum slightly exceeded the MCL at two locations (wells 0503 and 0505). However, molybdenum has also been identified as a common trace constituent in surface water contained in Goose Lake (Phillips and Van Denburgh 1971). A statement in the BLRA (DOE 1996a) asserted that “Molybdenum concentrations in contaminated groundwater are four times those of the geothermal background groundwater.” However, upon examination of the data in Table 3.3 of the BLRA, it was found that the reverse was true, that is, molybdenum concentration in the geothermal water was approximately four times greater than concentrations in the site-related groundwater. In 2002, molybdenum was below the risk-based concentration of 0.18 mg/L (EPA 2009) at all locations and below detection at most locations. Therefore, analysis for molybdenum was discontinued in 2004.
- **Chloride and Sodium:** Analysis of these constituents was discontinued after 2002 because it was determined that these nonregulated constituents were not significantly different from concentrations that would be expected within the basin.

Constituents retained in the monitoring plan after 2002 were manganese, sulfate, and uranium. Samples were collected in 2004, 2006, 2008, and 2010 for a limited monitoring well subset (five locations) of the 2002 monitored wells, and analyzed for those three analytes, as recommended in the previous version of this document. Analytical results from the 2004, 2006, and 2008 sampling events are shown in Table 2–2. These results indicate little difference in concentrations for most wells and for most analytes. Analytical results from the May 2010 sampling event are not yet available.

Table 2–2. Results of 2004, 2006, and 2008 Sampling and Analyses

Well No.	Year Sampled	Manganese (mg/L)	Sulfate (mg/L)	Uranium (mg/L)
0503	2004	7.8	2,500	0.0002
	2006	7.7	2,500	0.0002
	2008	7.5/7.7	2,300/2,400	NA
0505	2004	3.2	1,600	0.0004
	2006	2.7	1,600	0.0004
	2008	2.2	1,600	NA
0509	2004	0.098	30	0.0003
	2006	0.11	31	0.0004
	2008	0.62	33	0.000059/0.000074 ^a
0540	2004	24	1,400	0.011
	2006	26	1,400	0.010
	2008	17	1,200	0.0029 ¹
0543	2004	1.25	10	0.0007
	2006	1.10	8.1	0.0005
	2008	1.7	12	NA

^aUranium samples were inadvertently omitted during the 2008 sampling at wells 0509 and 0540. Off-schedule samples were collected in 2009 to make up for this omission.

Time-concentration graphs (Figure 2–6 and Figure 2–7) show little change in manganese and sulfate concentrations over time. An exception is well 0540, which has shown some variability in a number of constituent concentrations over time. A discussion of the three remaining COPCs (uranium, manganese, and sulfate) follows.

- **Uranium:** Monitoring well 0540 is located downgradient of the former tailings pile, and uranium in the groundwater was probably leached from the tailings. Uranium concentrations were slowly increasing in well 0540 from 1990 to 1999, and reached 0.057 mg/L in March 2002, exceeding the 40 CFR 192 standard of 0.044 mg/L. This is the only well in which the uranium concentration has ever exceeded the standard. In May 2004, the concentration of uranium dropped back below the standard to 0.011 mg/L, and in May 2006, the concentration was 0.010 mg/L. In July 2009, the concentration of uranium (0.0029 mg/L) in well 0540 remained below the standard for a third consecutive sampling event.

The nearest well downgradient from well 0540 is well 0509. The concentration of uranium in well 0509 has never exceeded the standard and has shown decreasing concentrations of uranium since monitoring began in 1985. Well 0509 contained 0.00003 mg/L of uranium in May 2004, 0.00004 mg/L in May 2006, and 0.000059 and 0.000074 mg/L (duplicate samples) in July 2009. Table 2–2 shows the more recent uranium groundwater sampling results. Uranium was analyzed from well 0540 and 0509 during the May 2010 sampling event. However, unless results from the May 2010 sampling exceed the standard, monitoring for uranium will be discontinued in all wells after 2010.

- **Manganese:** Manganese was an identified COPC in the BLRA and its inclusion in the groundwater monitoring program over time provide information helpful for characterizing the upper-most aquifer beneath the site. However, manganese is not a regulated constituent. Therefore, further mandatory assessment of manganese is not required.
- **Sulfate:** Sulfate was an identified COPC in the BLRA and its inclusion in the groundwater monitoring program over time provide information helpful for characterizing the upper-most aquifer beneath the site. However, sulfate is not a regulated constituent. Therefore, further mandatory assessment of sulfate is not required.

Therefore, it is concluded that no regulated, site-specific COPCs, as identified in the BLRA (DOE 1996a), are present in groundwater at or downgradient of the former milling operations at concentrations that exceed the applicable regulatory standards at 40 CFR 192.

2.4 Summary

Based on the above discussion, the following observations can be made about the Lakeview processing site:

- Regional groundwater is generally of poor quality and is affected by the dissolution of lacustrine sediments and the presence of a geothermal area.
- Site-related contamination appears to have largely attenuated. The area most likely to be influenced by site-related COPCs is within the current IC boundary.
- Groundwater is in compliance with standards for all constituents regulated under 40 CFR 192. No further remediation or monitoring is required.

3.0 Groundwater Compliance

3.1 Compliance Strategy Framework

The framework defined in the PEIS (DOE 1996b) governs selection of the strategy to achieve compliance with EPA groundwater standards. Stakeholder review of the final PEIS is documented and supported by the Record of Decision (*Federal Register* v. 62, No. 81, 1997). The framework used to determine the appropriate groundwater compliance strategy considers human health and environmental risk, stakeholder input, and cost. A step-by-step approach in the PEIS results in the selection of one of three general compliance strategies:

- **No remediation**—Compliance with the EPA groundwater protection standards would be met without altering the groundwater or cleaning it up in any way. This strategy could be applied for those constituents at or below MCLs or background levels or for those constituents above MCLs or background levels that qualify for supplemental standards or alternate concentration limits.
- **Natural flushing**—This strategy would allow natural groundwater movement and geochemical processes to decrease contaminant concentrations to regulatory limits. The natural flushing strategy can be applied where groundwater compliance could be achieved within 100 years, where effective monitoring and ICs can be maintained, and where the groundwater is not currently and is not projected to be a source for a public water system.
- **Active groundwater remediation**—This strategy would require engineered groundwater remediation methods such as gradient manipulation, groundwater extraction and treatment, land application, phytoremediation, and in situ groundwater treatment to achieve compliance with EPA standards.

3.2 Implementation

All of the 40 CFR 192 constituents identified at the Lakeview site have declined to below their respective standards. Because the remaining COPCs (sulfate and manganese) are not included as regulated constituents, the selected compliance strategy for the Lakeview site is no remediation. No additional groundwater monitoring or further actions beyond well decommissioning are required.

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4.0 References

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Appendix A

Voluntary Activities Work Plan

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1.0 Introduction

This document identifies the voluntary activities work approach which may be implemented by the U.S. Department of Energy (DOE) at the Lakeview, Oregon, Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I Processing Site. As established in the *Groundwater Compliance Action Plan* (GCAP) (June 2010), the Lakeview site is in compliance with the applicable Subpart B of Title 40 *Code of Federal Regulations* Part 192 requirements and no further groundwater remediation, monitoring, or actions are required by the DOE. However, because nonregulated, site-related constituents (sulfate and manganese) are present at levels exceeding background near the former mill site at concentrations that could pose a risk to human health and the environment, the DOE may continue to monitor these constituents in groundwater as a voluntary activity as described in Section 3.0 of this document.

DOE has also established an institutional control (IC) boundary that encompasses groundwater potentially affected by site-related activities and prohibits the completion of domestic-use wells at depths shallower than 250 feet (ft) to ensure protectiveness of human health and the environment. City water was provided to the area for domestic use as part of the IC effort. (See discussion in Appendix B of the GCAP for additional information.) It is likely that these ICs will continue to be maintained.

Depending upon the analytical results of the May 2010 groundwater sampling, these activities may be implemented beginning in 2012. These voluntary activities may be conducted solely per DOE discretion and may change as additional information is obtained and conditions are reassessed.

As voluntary activities associated with nonregulated constituents, U.S. Nuclear Regulatory Agency concurrence is not required for these activities.

2.0 Basis for Voluntary Activities

Information pertaining to the distributions of site-related sulfate and manganese and human health and environmental risks potentially associated with these constituents are discussed in this section.

2.1 Distribution of Sulfate and Manganese

Manganese: Manganese has relatively low mobility in groundwater and tends to precipitate or adsorb in the subsurface, particularly where oxidizing conditions exist, as in the shallow aquifer at Lakeview (DOE 1996a). Any site-related manganese probably did not migrate extensively from the former mill site.

Based on historical mill site data, manganese was clearly associated with the tailings fluid and, to a lesser extent, the raffinate pond. Concentrations of manganese remain high in the vicinity of these former site-related source areas. The time-concentration graph for manganese (shown as Figure 2-6 in the GCAP) shows little change, with the exception of well 0540, which has shown some variability over time. A spot plot for manganese is included as Figure 2-8 in the GCAP. It was generated for the 2002 version of the GCAP and shows manganese concentrations in

groundwater and surface water at various monitoring locations. Circles on the figure indicate results of the comprehensive (one-time) March 2002 sample round; squares on the figure indicate where samples were collected in 1999 but could not be collected in 2002. Table 1 shows the more recent manganese groundwater sampling results.

Table 1. Results of 2004, 2006, and 2008 Sampling and Analyses

Well No.	Year Sampled	Manganese (mg/L)	Sulfate (mg/L)	Uranium (mg/L)
0503	2004	7.8	2,500	0.0002
	2006	7.7	2,500	0.0002
	2008	7.5/7.7	2,300/2,400	NA
0505	2004	3.2	1,600	0.0004
	2006	2.7	1,600	0.0004
	2008	2.2	1,600	NA
0509	2004	0.098	30	0.0003
	2006	0.11	31	0.0004
	2008	0.62	33	0.000059/0.000074 ^a
0540	2004	24	1,400	0.011
	2006	26	1,400	0.010
	2008	17	1,200	0.0029 ¹
0543	2004	1.25	10	0.0007
	2006	1.10	8.1	0.0005
	2008	1.7	12	NA

^aUranium samples were inadvertently omitted during the 2008 sampling at wells 0509 and 0540. Off-schedule samples were collected in 2009 to make up for this omission.

Sulfate: Sulfate, a product of sulfuric acid used in the milling process, tends to be very mobile. It is commonly used as an indicator of milling-related contamination. Sulfate, because of its higher mobility, is a good indicator of the extent of site-related effects near the Lakeview site.

Based on historical mill site data, sulfate was present in the tailings fluids and, to a lesser extent, in the raffinate pond. Concentrations of sulfate are still relatively high in the vicinity of these former site-related source areas. The time-concentration graph for sulfate (Figure 2–7 in the GCAP) shows little change. An exception is well 0540, which has shown some variability in sulfate concentrations over time.

A spot plot for sulfate generated for the 2002 GCAP is included as Figure 2–9 in the GCAP. The figure shows sulfate concentrations in groundwater and surface water at various monitoring locations. Circles on the figure indicate results of the comprehensive (one-time) March 2002 sample round; squares on the figure indicate where samples were collected in 1999 but could not be collected in 2002. Table 1 shows the more recent sulfate groundwater sampling results.

Where sulfate concentrations in the vicinity of the site are in the hundreds of milligrams per liter, it is difficult to determine whether the sulfate is naturally occurring or site related. The higher levels of sulfate in wells 0503 and 0540 (1,600 mg/L or greater) are indicative of site-related effects, and these wells are located near source areas. However, farther downgradient, the distinction becomes problematic. For example, the sulfate level in well 0518 was 429 mg/L in 2002, and it is downgradient from the site. However, similar concentrations have been observed in wells outside the influence of the site (e.g., south of the site on Roberta Avenue). To further

complicate the interpretation of data from well 0518, the sulfur isotopic analyses show that the water has a geothermal signature. Therefore, it is inconclusive whether the sulfate (and manganese) in well 0518 derives from site activities. This example illustrates the difficulty of basing the extent of site-related effects on a numerical value.

Concentrations of sulfate in well 0505, which is located at the edge of the IC boundary, have been relatively high (1,600 mg/L) for the last several monitoring events. To better define the downgradient edge of site-related sulfate and to ensure that unacceptable levels of sulfate and manganese do not move beyond the IC boundary undetected, it may be necessary to install additional downgradient monitoring wells. This is discussed further in Section 4.0 of this work plan.

2.2 Human Health and Environmental Risks

Sulfate and manganese are not regulated in drinking water. However, EPA has established secondary drinking water standards for sulfate and manganese of 250 mg/L and 0.05 mg/L, respectively. The basis for these secondary standards is aesthetic (e.g., issues of taste or smell) rather than risk or health. However, as required by the Safe Drinking Water Act, EPA reviewed and compiled a significant amount of health-related data on these two constituents to determine whether their regulation would provide a benefit to public health. Because the main goal of DOE's voluntary monitoring activity at Lakeview is to ensure protectiveness from elevated site-related constituents, information from relevant health studies is provided in the discussion of potential human health risks associated with use of groundwater at the Lakeview processing site. A consideration of potential ecological risks is also provided.

Because the use of water within the IC boundary is restricted, the main concern is whether elevated site-related constituents could migrate beyond the IC boundary and pose an unacceptable risk. Monitoring data from 2008 show that well 0505 at the downgradient edge of the IC boundary had manganese and sulfate concentrations of 2.2 mg/L and 1,600 mg/L, respectively. The primary exposure pathway of concern for human health beyond the IC boundary is assumed to be ingestion of groundwater as drinking water. Contribution of risk from other potential pathways (e.g., dermal exposure, vapor inhalation) is insignificant compared to water ingestion.

2.2.1 Manganese

Manganese is an essential nutrient for human health. It is ubiquitous at low levels in soil, water, air, and food (EPA 2003a). The toxicity of manganese through oral ingestion is considered to be low. It is most toxic when inhaled as a dust. As noted, the secondary standard for manganese of 0.05 mg/L is based on aesthetic considerations. The World Health Organization (WHO) has identified levels of constituents in water for which water quality would be deemed unacceptable based on considerations of appearance, taste, and odor (WHO 2008). At concentrations greater than 0.1 mg/L, manganese can leave an undesirable taste in water and other beverages. At a concentration of 0.2 mg/L, it may form a coating on pipes, which can slough off as a black slime. The WHO health-based guideline is 4 times higher than the acceptability threshold of 0.1 mg/L. The undesirable taste and appearance of the water discourages use of untreated water at levels below which any health concerns for manganese exist.

Several studies have examined the intake level of manganese that may be considered safe for humans. The Estimated Safe and Adequate Daily Dietary Intake for manganese has been

established at 2–5 mg/day for adults (NRC 1989); however, higher levels have been found to result in no adverse effects. In 2001, the Institute of Medicine set a tolerable upper intake level (TUIL) of 11 mg/day for adults. It has been suggested that people eating western–hemisphere-type and vegetarian diets may have intakes as high as 10.9 mg/day of manganese (ATSDR 2008). An interim guidance value of 0.16 mg manganese per kilogram (kg) of body weight per day is recommended for ATSDR public health assessments of oral exposure to inorganic forms of manganese (ATSDR 2008). This guidance value is based on the TUIL of 11 mg manganese per day for 70 kg adults (established by the U.S. Food and Nutrition Board/Institute of Medicine [FNB/IOM 2001]). This level would take into account all sources of dietary manganese, including food and water.

If all dietary manganese for a 70 kg adult was obtained from drinking water, a maximum drinking water concentration based on the TUIL would be 5.6 mg/L (assuming the EPA default ingestion rate of drinking water of 2 liters per day). In practice, because of the numerous dietary sources of manganese, this upper bound number would be considered too high to be safe, but it is useful to keep in mind when evaluating data from the Lakeview site.

EPA has established a lifetime health advisory for manganese of 0.3 mg/L and a drinking water equivalent level (DWEL) of 1.6 mg/L (EPA 2006). The DWEL is a safe level for exposure over a lifetime, assuming all exposure to a chemical is through drinking water. The lifetime health advisory is a level that is not expected to cause any adverse effects for a lifetime of exposure, but takes into account other non-drinking-water sources of a chemical. The concentration of manganese in the IC boundary well 0505 is higher than EPA's secondary standard, health advisory, and DWEL, but less than an upper bound based on the TUIL. While ingesting water with this level of manganese could have some deleterious effects, use of untreated water would be highly discouraged because of undesirable aesthetic effects that would accompany these concentrations. It should be noted that wells near the Lakeview site that are outside of both the influence of the elevated site-related constituents and the IC boundary have shown manganese concentration up to 26.1 mg/L, which is also higher than the EPA's secondary standard and any health-based number.

2.2.2 Sulfate

The EPA and Centers for Disease Control (CDC) conducted studies on human consumption of sulfate-contaminated water as part of the effort to determine if sulfate should be regulated in drinking water supplies (EPA 1999). Subjects were adults exposed to levels of up to 1,200 mg/L of sulfate. The study showed that laxative effects can occur at concentrations somewhere above about 500 to 1,000 mg/L, but that these effects are usually temporary.

From this study, EPA and CDC jointly concluded it is unlikely that any adverse health effects will result from sulfate concentrations in drinking water below 600 mg/L for adults. They also noted that people can develop a tolerance for high concentrations of sulfate in drinking water. Also, because of the unpleasant taste of water high in sulfate (the taste threshold for sulfate is 250 mg/L), people tend to decrease the amount of high-sulfate water they drink at one time, thus reducing the likelihood of acute exposure. The WHO's acceptability threshold ranges from 250 mg/L (for sodium sulfate) to 1,000 mg/L (for calcium sulfate; WHO 2008).

A South Dakota study was conducted to determine the risk for diarrhea in infants exposed to high levels of sulfate in tap water compared to the risk for those unexposed (Esteban et al. 1997).

The study examined levels ranging from 0 to 2,787 mg/L sulfate (mean of 264 mg/L) and found no significant association between sulfate levels and the incidence of diarrhea. The EPA and CDC planned to further investigate the effects of sulfate intakes on infants during their study, but were unable to identify a large enough number of exposed individuals to draw a study population (EPA 1999).

An expert panel of scientists convened in September 1998 to supplement the EPA/CDC study concluded there was insufficient scientific evidence regarding health effects to justify a regulation, and suggested that a health advisory be issued in areas where sulfate concentrations in drinking water exceed 500 mg/L. (EPA 2003b).

Concentrations of sulfate at the IC boundary exceed the levels recommended by EPA. Levels in well 0518 are below levels that could cause laxative effects. Use of untreated water with sulfate concentrations above 1,000 mg/L would be discouraged based on taste. This would discourage the use of water with elevated concentrations that could result in adverse health effects. As with manganese, it should be noted that wells near the Lakeview site that are outside of both the influence of the elevated site-related constituents and the IC boundary have shown sulfate concentrations up to 1,460 mg/L, which is also higher than the EPA's secondary standard and its health advisory.

2.2.3 Potential Ecological Risks

A limited ecological evaluation was performed for this site in the BLRA. That evaluation concluded that there is a low potential to threaten the food chain (through bioaccumulation and biomagnification) of terrestrial and aquatic wildlife. However, the BLRA identified two potential areas of concern: (1) phytotoxicity of plants that have roots in direct contact with the aquifer and (2) use of groundwater as a long-term source of drinking water for livestock. Visual reconnaissance of the former mill site has indicated that no negative impacts on vegetation are occurring as a result of groundwater constituents, so phytotoxicity does not appear to be an issue.

Several studies indicate that no harmful effects would be expected in cattle and poultry ingesting from 1,500 to 2,500 mg/L of sulfate in drinking water, except some temporary diarrhea. Some general recommendations for limits on sulfate in livestock water are on the order of 500 to 1,000 mg/L (variety of state extension service offices including Kentucky, Kansas, and Oklahoma). Some states have adopted groundwater standards or guidelines for waters that may be used for agriculture. Oregon does not have a sulfate standard specifically for livestock watering. However, the sulfate standard adopted by the State of Wyoming for agricultural use is 3,000 mg/L. Based on the above, it is likely that site-related sulfate in groundwater outside the IC boundary would be protective of livestock use.

Guidelines for the agricultural use of manganese are very low compared to concentrations observed in the Lakeview area. Livestock benchmarks and standards are generally at or below 0.5 mg/L. This suggests that the general shallow groundwater quality in the Lakeview area would not be a suitable source of water for livestock watering.

3.0 Voluntary Groundwater Monitoring Plan

The only remaining indicator constituents of site-related effects to groundwater are sulfate and manganese. DOE is committed to continuing the monitoring of these two constituents as a voluntary activity for a reasonable period of time to ensure protectiveness of human health and the environment. As part of this monitoring, DOE may assess the adequacy of the area located immediately current, hydraulically downgradient IC boundary. These activities may be implemented beginning in 2012, and would be conducted solely per DOE discretion; the monitoring plan may change as additional information is obtained and conditions are reassessed.

Basic Monitoring Approach:

The “basic” voluntary monitoring approach may consist of sampling wells 0503, 0505, 0509, 0540, and 0543 every other year for sulfate and manganese analysis. The basic monitoring network is shown in Figure 1 and the corresponding monitoring objectives are summarized in Table 2.

Table 2. Summary of Basic Monitoring Network

Well Number	Depth to Top of Well Screen (ft below ground surface)	Monitoring Locations	Analytes	Frequency
LKV-0503	18.16 ^a	Highest concentration downgradient of raffinate ponds.	Sulfate and manganese	Biennial. The need for continued monitoring may be reassessed as analytical data becomes available.
LKV-0505	21.10 ^a	Downgradient of raffinate ponds and well 0503.		
LKV-0540	25.04 ^a	Highest concentration downgradient of former tailings pile		
LKV-0543	132	Private domestic use well along Missouri Ave. Well is completed inside the IC boundary. Monitoring may help ensure that adequate water quality is maintained.		
LKV-0509	26.92 ^a	Downgradient of former tailings pile and well 0540.		

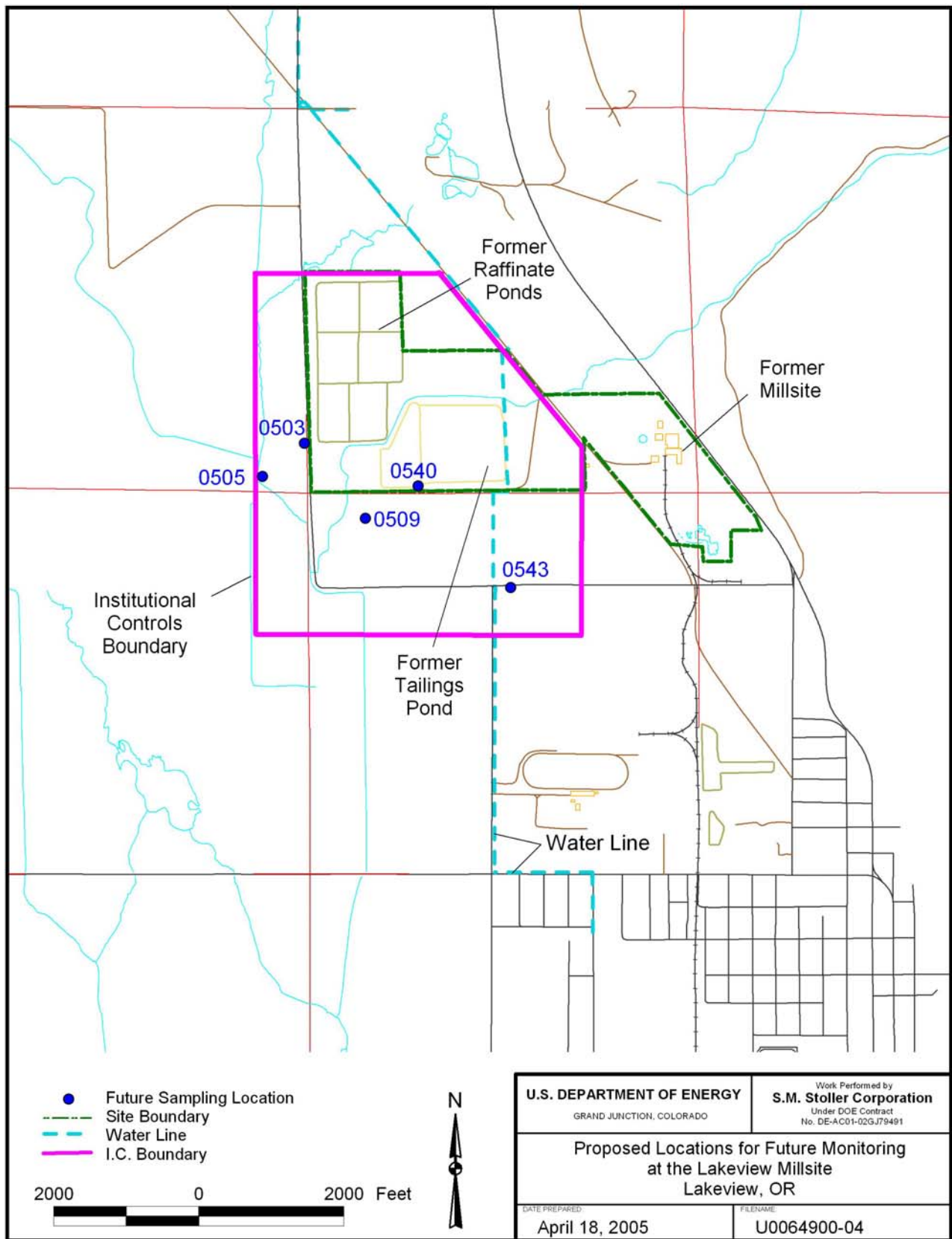
^a Well screen length is 5 ft.

Year 2012:

Because the source(s) of the sulfate and manganese are ambiguous, a sulfur isotope analysis and well 0518 (shown on Figure 2) are being added to the basic monitoring approach in 2012 only to better assess the geothermal influence in the vicinity of the current downgradient IC boundary, as represented by well 0505. This additional information may help with the assessment of the adequacy of the downgradient IC boundary.

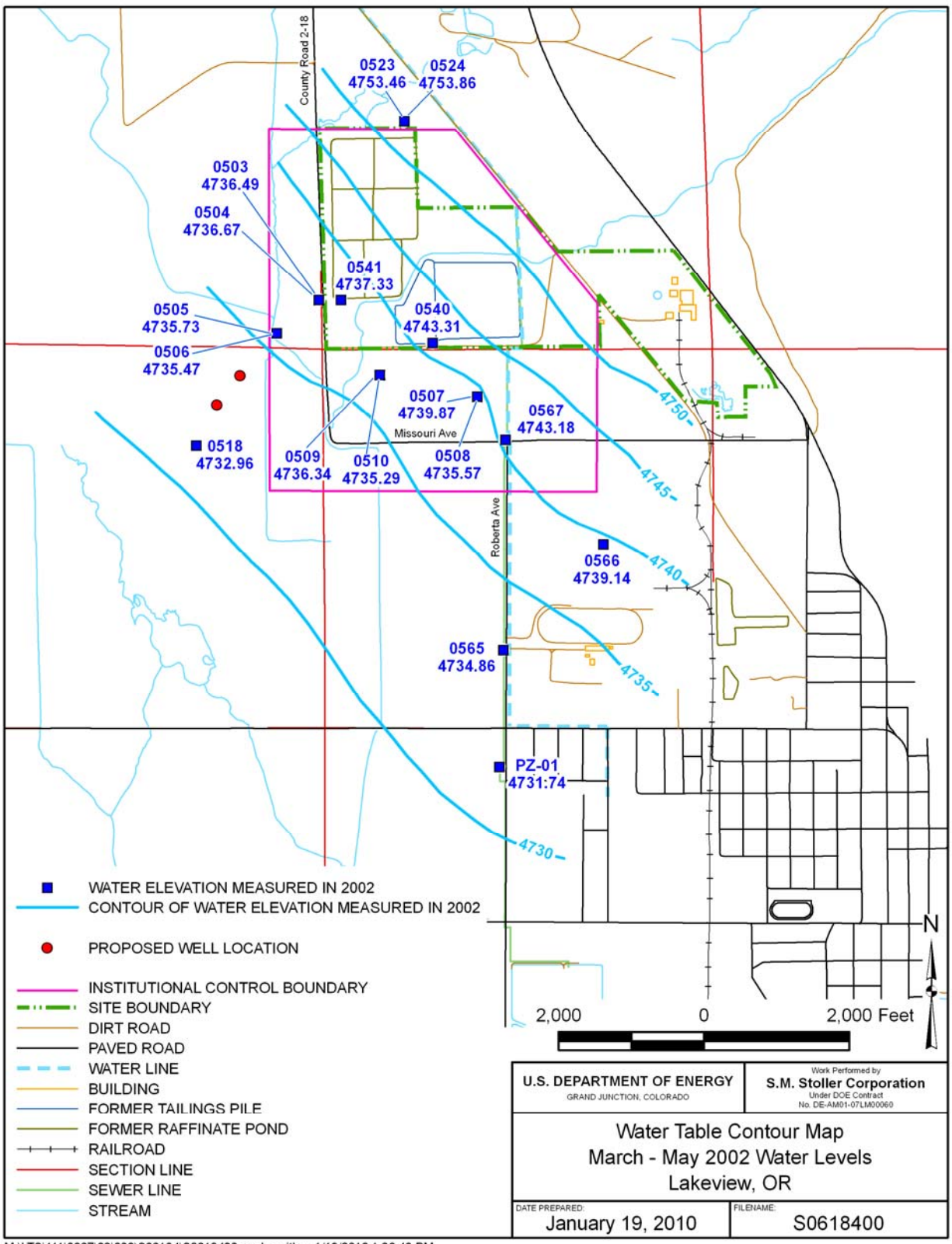
If the 2012 analytical results indicate that:

- There is a geothermal influence in well 0505, and the sulfate in this well can be attributed to this source, then no additional wells may be needed to delineate site-related effects and it may be determined that site-related COPCs are adequately delineated and that the previously identified basic monitoring approach is adequate to ensure that elevated site-related constituents do not leave the IC boundary undetected.



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Figure 1. Basic Monitoring Network for Voluntary Monitoring at the Lakeview Mill Site, Lakeview, Oregon



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Figure 2. Approximate Locations of Proposed New Wells Shown on Water Table Contour Map

- The sulfate in 0505 is only site-related, and sulfate concentrations remain relatively high, then DOE may assess the need for installing two additional downgradient monitoring wells prior to the 2014 sampling event to further delineate the extent of site-related sulfate and manganese.

The new wells, if warranted, would likely be located hydraulically downgradient (southwest) of the former raffinate ponds area and west of the current IC boundary between the west IC boundary near well 0505 and existing well 0518.

The approximate locations of the new wells are shown on Figure 2. These proposed locations may change depending on the results of the 2012 analyses.

Future Monitoring:

If additional wells are not warranted, then the basic monitoring approach may continue to be implemented on a voluntary, as-needed basis. If new wells are installed, the new wells, and possibly well 0518, may be added to the basic monitoring approach.

At the conclusion of the voluntary activities, DOE may decommission all monitoring wells in accordance with applicable State of Oregon regulations.

Institutional Controls:

DOE might determine that the existing IC boundary needs to be extended to the west and south to ensure continued protectiveness from site-related sulfate and/or manganese.

For informational purposes, an assessment of the Oregon Water Resources Department well log records in the areas immediately down gradient (within 0.25 miles) of the current IC boundary and the site-related COPCs was conducted in April 2010 to determine if domestic wells are reported in those areas. Results of the assessment are summarized in Table 3. The specific areas assessed within Township 39 South, Range 20 East are shown on Figure 3.

Table 3. Existing Wells Down-Gradient of the Existing IC Boundary^a

Township 39 South, Range 20 East ^b		Wells Reported (Well Log Number)	Completed Depth (feet below ground surface)	Use	Owner
Section	Quarter Quarter, Quarter (Quadrant)				
5	N/A, SE	LAKE_2401	48.00	Unspecified	Swingle, Cecil OR
8	N/A, NW	LAKE_2423	300.00	Irrigation	Plato, Lytton 1038 North 2 nd Lakeview, OR
8	SW, NW	LAKE_51798	70.00	Domestic	Breshears, Wayne 94969 HWY 140 W Lakeview, OR

a DOE-owned wells are not included on this table.

b The southeast quarter of section 5 was assessed. The northern half of section 8 was assessed. The northwest and southwest quarter quarters of the northwest quarter of section 9 were assessed.

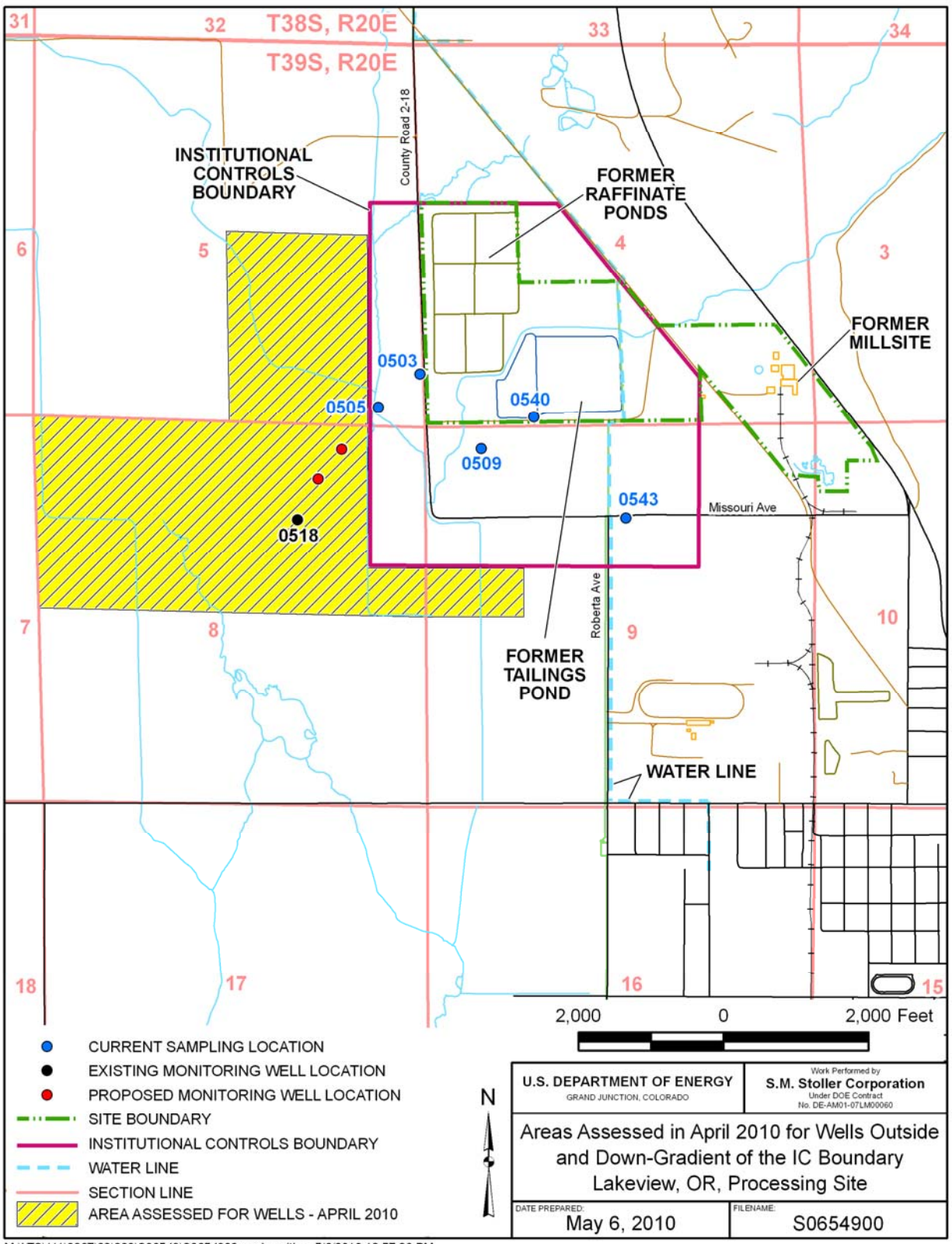


Figure 3. Areas Assessed in April 2010 for Wells Outside and Down-Gradient of the Existing IC Boundary

4.0 References

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Appendix B

Institutional Controls

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Institutional Controls

Institutional controls (ICs) were implemented at the Lakeview site to limit access to groundwater potentially impacted by milling activities by providing city water to the area residents.

The ICs were implemented in a two-part effort. An IC boundary was established around the western part of the former mill site that included land containing and extending beyond probable mill site effects based on sulfate concentrations (Plate 1). DOE negotiated with the town of Lakeview and Lake County officials to increase the diameter of a domestic water line (in the IC area) that was being constructed from the town of Lakeview to a new state prison located north of town. This construction was completed in the spring through fall of 2002. The corridor for the water line to the prison intersects the southern and eastern sides of the IC area and provides municipal water to residents inside the zone. DOE paid \$200,000 to fund this difference in cost for the water line. In exchange, the town of Lakeview and Lake County both passed ordinances requiring future land users inside an IC area to obtain hookups from the new domestic water line or be required to drill a well to a depth that will guarantee no potential milling-related constituents are encountered.

The second part of this IC was the establishment of a minimum depth to which a well must be drilled before water is used for drinking purposes. DOE reviewed well pair chemistry that suggested no elevated site-related constituents are present at depths greater than 100 feet (ft). This depth is comparable to anecdotal information from an experienced well driller, indicating that good water throughout the area is usually found at depths greater than 60 ft. To investigate this question further, DOE sampled and analyzed water from several municipal or multi-use domestic wells in the mill site area during the 2002 sampling event. Wells 0557, 0558, and 0562 (shown on Plate 1) are 300 to 400 ft deep and all produce large volumes of potable water. Results showed good quality water with relatively low TDS. The Oregon Water Resources Commission concurred with DOE's proposal to require that the top of the screened interval in all domestic wells installed in the IC area be at least 250 ft below ground surface. The 250 ft was considered to be a conservative depth. Exclusion of the upper 250 ft for domestic groundwater use within the IC boundary was codified by the Oregon Water Resources Commission, an office within the Oregon Water Resources Department, in Salem, Oregon, on March 12, 2004. This is the state agency responsible for ensuring that domestic well applications are reviewed and approved before drilling permits are issued. The content of the ruling titled *Special Area Well Construction Standards—Lakeview, Oregon*, OAR Chapter 690, Division 200, was previously provided in prior drafts of this Groundwater Compliance Action Plan.

No one is drinking affected water from private, domestic wells inside the IC boundary. Although one resident within the IC boundary has a private drinking water well that is less than 250 ft in depth, this well (0543) produces high-quality water. To ensure compliance with the IC boundary, DOE visited the owners in 2005 and in 2009 in an attempt to provide them with a hookup to municipal water or to drill a deeper well. The State of Oregon has also had similar discussions with the owners. The residents currently have clean, cold, good-tasting drinking water and are not interested in any action that might alter this situation.

Well 0543 is completed at 155 ft and is located more than 1,000 ft cross-gradient from the site boundary. It has very low sulfate, which, although nonregulated, is the main site-related indicator. Based on its location, depth, and low sulfate concentrations, it is concluded that this

well will not be affected by the site in the future. This well does have elevated manganese concentrations, but it is within the range of manganese observed in other wells outside the site influence, such as those on Roberta Avenue. DOE has determined that well 0543 will not be affected by site-related constituents and additional monitoring of this well is not required to ensure that adequate water quality is maintained. DOE recommends that when ownership of the property changes, that the new owner tie into the city water supply line.

NRC stated that DOE can consider well 0543 grandfathered in under the IC restrictions and the State of Oregon has concurred with the concept that there are some pockets of relatively good quality water within the IC area.

Appendix C

Pore Water Results from the Raffinate Ponds and Tailings Piles, and Sulfur Isotopes Figure

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Table B.3.1 Lakeview pore water samples

Constituent	Number of samples	All concentrations in mg/l ^a			Arithmetic mean	Geometric mean
		Maximum	Minimum	Median		
Pile (primarily from slimes)						
Arsenic	6	2.19	0.012	0.078	0.535	0.122
Cadmium	6	0.249	<0.001	0.114	0.110	0.043
Molybdenum	5	0.03	<0.001	0.02	0.018	0.014
Uranium	6	0.30	0.01	0.075	0.107	0.061
Sulfate	6	12,700.0	2400.0	3400.0	6000.0	4940.0
Manganese	6	81.5	1.32	24.7	35.2	18.6
Iron	6	1.65	0.04	0.17	0.54	0.68
Aluminum	6	979.0	0.20	200.0	333.0	72.0
Raffinate pond						
Arsenic	19	0.084	<0.01	0.01	0.029	0.016
Molybdenum	18	0.25	<0.01	0.01	0.038	0.014
Uranium	20	0.18	0.01	0.02	0.03	0.02
Sulfate	18	1600.0	840.0	1150.0	1136.0	1117.0
Manganese	20	2.64	1.09	1.78	1.68	1.63
Iron	19	4.2	<0.03	0.03	0.26	0.037
Aluminum	19	10.8	1.3	5.2	6.3	5.4

^amg/l = milligrams per liter.

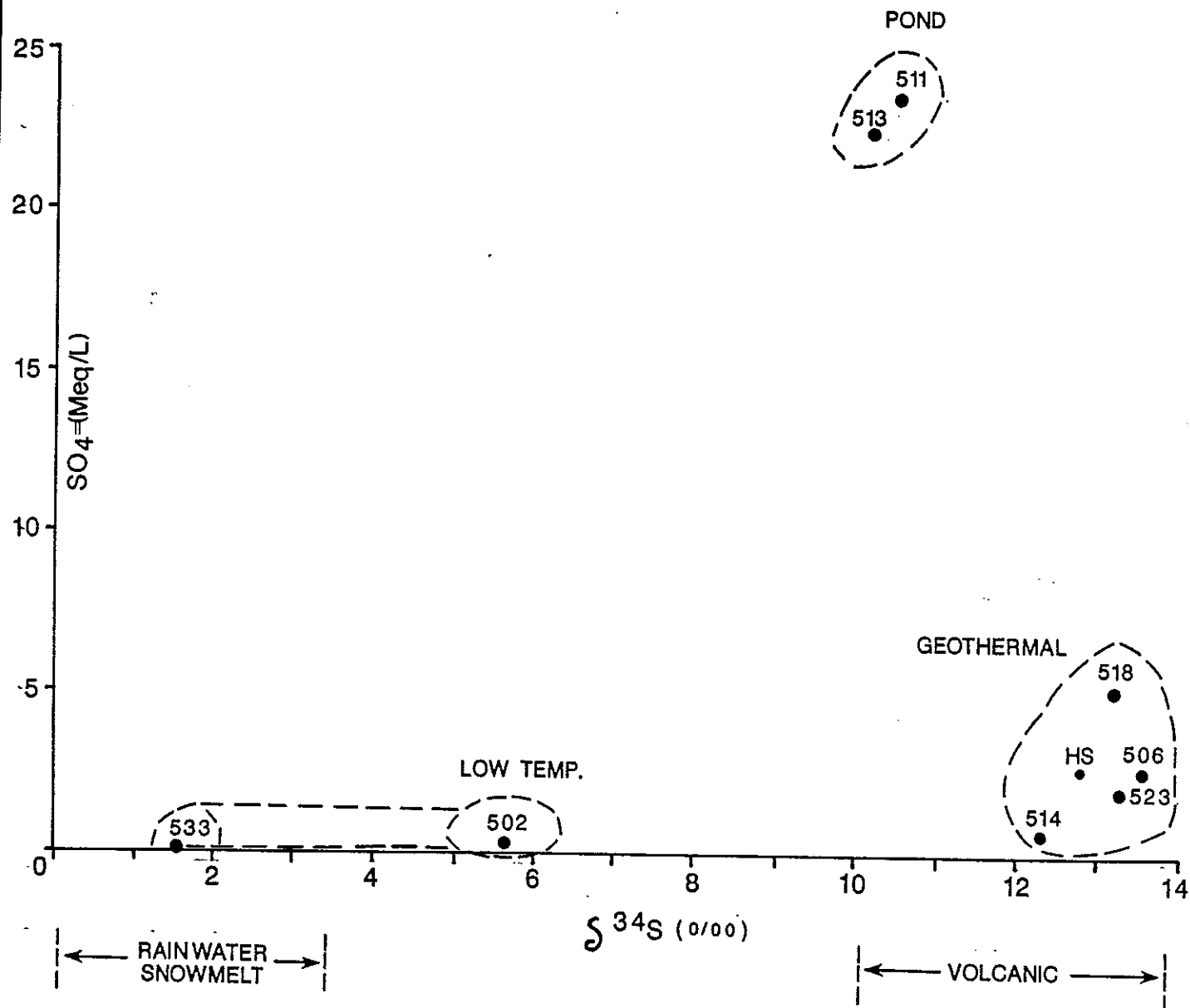
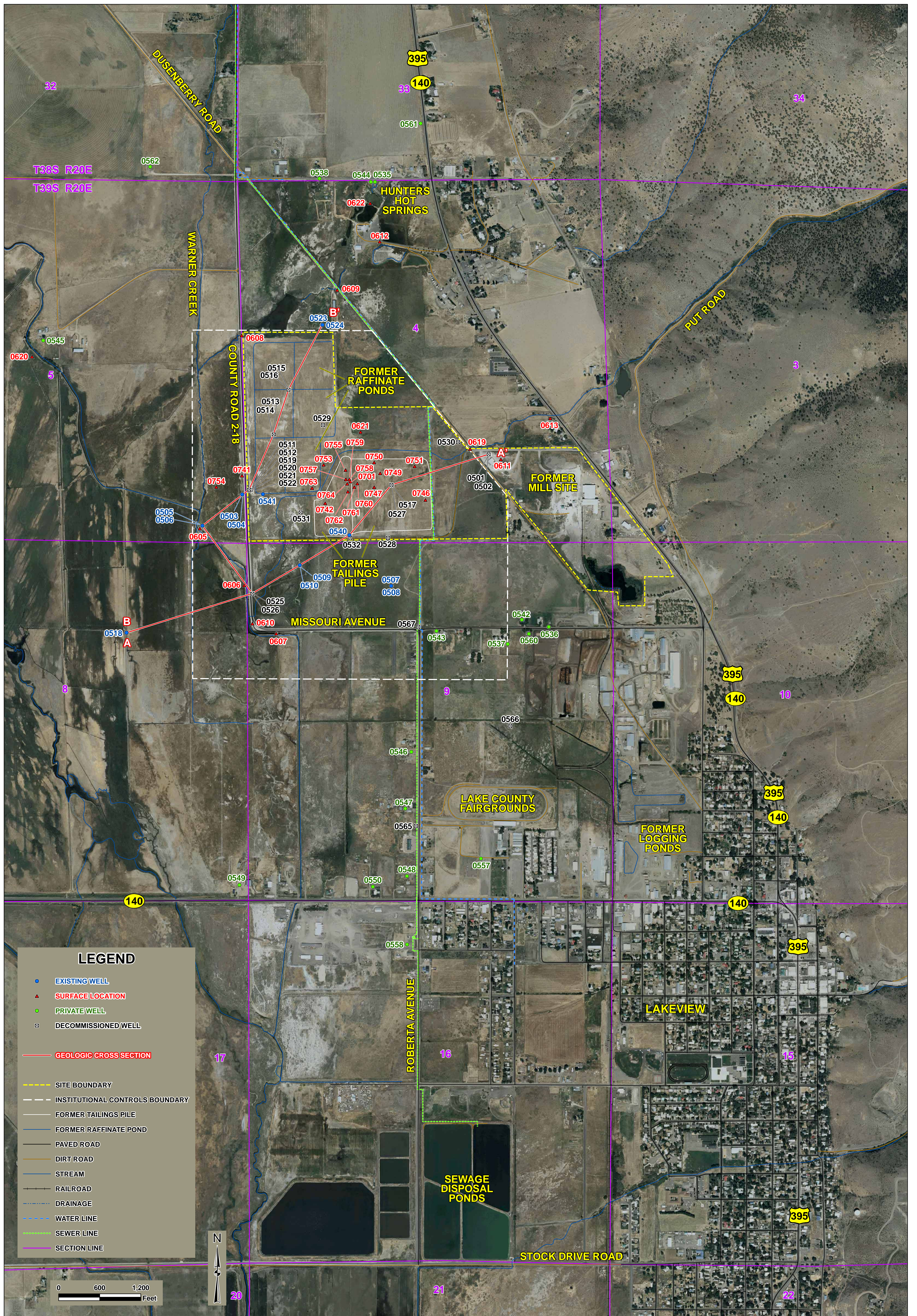
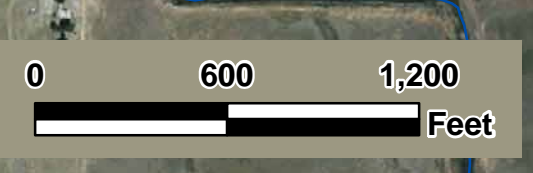


FIGURE B.3.4
DISTRIBUTION OF SULFATE CONCENTRATION vs.
SULFUR-34 ISOTOPE RATIO



LEGEND

- EXISTING WELL
- ▲ SURFACE LOCATION
- PRIVATE WELL
- DECOMMISSIONED WELL
- GEOLGIC CROSS SECTION
- - - SITE BOUNDARY
- - - INSTITUTIONAL CONTROLS BOUNDARY
- FORMER TAILINGS PILE
- FORMER RAFFINATE POND
- PAVED ROAD
- DIRT ROAD
- STREAM
- RAILROAD
- DRAINAGE
- WATER LINE
- SEWER LINE
- SECTION LINE



U.S. DEPARTMENT OF ENERGY GRAND JUNCTION, COLORADO	Work Performed by S.M. Stoller Corporation Under DOE Contract No. DE-AM01-07LA00060
Plate 1: Lakeview, OR, Processing Site Base Map with 2005 Photo Base	
DATE PREPARED January 28, 2010	FILENAME S0622000